Attorney Docket 0553-0381

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:		)
	Shunpei YAMAZAKI et al.	)
Serial No.:	10/705,604	)
Filed:	November 10, 2003	)
For: Manufacturing Method Of Emitting Device		)
Examiner:	James Lin	)
Confirm No.:	6065	)
Art Unit:	1762	)

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

TRANSMITTAL OF VERIFIED ENGLISH TRANSLATION OF PRIORITY DOCUMENT

Sir:

Applicants are submitting herewith a verified English translation of the priority document Japanese patent application serial number 2002-327373 filed November 11, 2002 in Japan. A certified copy of this priority document has already been filed in this application on November 10, 2003.

Accordingly, the present application is entitled to claim the benefit of the November 11, 2002 filing date of Japanese patent application serial number 2002-327373.

Respectfully submitted,

Date: November 27, 2007

/Mark J. Murphy/
Mark J. Murphy
Registration No. 34,225

COOK, ALEX, McFARRON, MANZO,
CUMMINGS & MEHLER, LTD.
200 West Adams Street, Suite 2850
Chicago, Illinois 60606
(312) 236-8500

Customer No. 26568

Docket No.: 0553-0381

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of: Yamazaki et al.)
Application No.: 10/705604) Examiner: J. LIN
Filed: November 10, 2003) Group Art Unit: 1762
For: MANUFACTURING METHOD OF EMITTING DEVICE)

VERIFICATION OF TRANSLATION

Commissioner for Patents
P.O.Box 1450
Alexandria, VA 22313-1450

Sir:

I, Yukiko Kokubu, C/O Semiconductor Energy Laboratory Co., Ltd. 398, Hase, Atsugi-shi, Kanagawa-ken 243-0036 Japan, a translator, herewith declare:

that I am well acquainted with both the Japanese and English Languages;

that I am the translator of the attached translation of the JP Patent Application No. 2002-327373 filed on November 11, 2002; and

that to the best of my knowledge and belief the following is a true and correct translation of the JP Patent Application No. 2002-327373 filed on November 11, 2002.

I further declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Date: this 8th day of November

Yukiko Kokubu

Name: Yukiko Kokubu

[Name of Document] Patent Application

[Reference Number] P006720

[Filing Date] November 11, 2002

[Attention] Commissioner, Patent Office

[Inventor]

[Address] 398, Hase, Atsugi-shi, Kanagawa-ken c/o Semiconductor Energy Laboratory Co., Ltd.

[Name] Shunpei YAMAZAKI

[Inventor]

[Address] 398, Hase, Atsugi-shi, Kanagawa-ken c/o Semiconductor Energy Laboratory Co., Ltd.

[Name] Masakazu MURAKAMI

Inventor]

[Address] 398, Hase, Atsugi-shi, Kanagawa-ken c/o Semiconductor Energy Laboratory Co., Ltd.

[Name] Ryoji NOMURA

Inventor]

[Address] 398, Hase, Atsugi-shi, Kanagawa-ken c/o Semiconductor Energy Laboratory Co., Ltd.

[Name] Satoshi SEO

[Applicant]

[Identification Number] 000153878

[Name] Semiconductor Energy Laboratory Co., Ltd.

[Representative] Shunpei YAMAZAKI

[Indication of Handlings]

[Number of Prepayment Note] 002543

[Payment Amount] 21,000

[List of Attachment]

[Attachment] Specification 1

[Attachment] Drawing 1

[Attachment] Abstract 1

[Proof] required

[Name of Document] Specification

[Title of the Invention] MANUFACTURING METHOD OF LIGHT EMITTING DEVICE

[Scope of Claims]

[Claim 1]

1. A fabrication method of a light-emitting device characterized by:

ejecting a solution containing a light-emitting body composition from the below toward an anode or a cathode under a pressure lower than atmospheric pressure; and

depositing the light-emitting body composition on the anode or the cathode,

whereby forming a thin film having at least one layer structuring a light-emitting body.

2. A fabrication method of a light-emitting device characterized by:

ejecting a solution containing a light-emitting body composition from the below toward an anode or a cathode under a pressure of 1×10^2 to 1×10^5 Pa, preferably 1×10^3 to 1×10^4 Pa; and

depositing the light-emitting body composition on the anode or the cathode,

whereby forming a thin film having at least one layer structuring a light-emitting body.

3. A fabrication method of a light-emitting device characterized by:

ejecting a solution containing a light-emitting body composition from the below toward an anode or a cathode under a pressure lower than atmospheric pressure; and

depositing a remaining of the light-emitting body composition on the anode or the cathode and volatilizing a solvent in the solution while the solution travels to the anode or the cathode,

whereby forming a thin film having at least one layer structuring a light-emitting body.

4. A fabrication method of a light-emitting device characterized by:

ejecting a solution containing a light-emitting body composition from the below toward an anode or a cathode under a pressure lower than atmospheric pressure;

making a solvent in the solution start to volatilize simultaneously with an arrival thereof at the anode or the cathode by previously heating the anode or the cathode; and

depositing a remaining of the light-emitting body composition on the anode or the cathode,

whereby forming a thin film having at least one layer structuring a light-emitting body.

5. A fabrication method of a light-emitting device characterized by:

ejecting a solution containing a light-emitting body composition from the below toward an anode or a cathode under a pressure lower than atmospheric pressure;

making a solvent in the solution start to volatilize simultaneously with an arrival thereof at the anode or the cathode by previously heating the anode or the cathode from room temperature to 200 °C; and

depositing a remaining of the light-emitting body composition on the anode or the cathode,

whereby forming a thin film having at least one layer structuring a light-emitting body.

6. A fabrication method of a light-emitting device characterized by:

setting up an anode or a cathode in a range of 0° to 30° relative to a horizontal plane;

ejecting a solution containing a light-emitting body composition from below the anode or the cathode under a pressure lower than atmospheric pressure; and

depositing a remaining of the light-emitting body composition on the anode or the cathode,

whereby forming a thin film having at least one layer structuring a light-emitting body.

7. A fabrication method of a light-emitting device characterized by:

setting up an anode or a cathode in a range of 0° to 30° relative to a horizontal plane;

ejecting a solution containing a light-emitting body composition from below the anode or the cathode under a pressure lower than atmospheric pressure; and

depositing a remaining of the light-emitting body composition on the anode or the cathode and volatilizing a solvent in the solution while the solution travels to the substrate,

whereby forming a thin film having at least one layer structuring a light-emitting body.

8. A fabrication method of a light-emitting device characterized by:

setting up an anode or a cathode in a range of 0 ° to 30° relative to a horizontal plane;

ejecting a solution containing a light-emitting body composition from below the anode or the cathode under a pressure lower than atmospheric pressure;

making a solvent in the solution start to volatilize simultaneously with an arrival thereof at the anode or the cathode by previously heating the anode or the cathode; and

depositing a remaining of the light-emitting body composition on the anode or the cathode,

whereby forming a thin film having at least one layer structuring a light-emitting body.

9. A fabrication method of a light-emitting device characterized by:

setting up an anode or a cathode in a range of 0° to 30° relative to a horizontal plane;

ejecting a solution containing a light-emitting body composition from below the anode or the cathode under a pressure lower than atmospheric pressure;

making a solvent in the solution start to volatilize simultaneously with an arrival thereof at the anode or the cathode by previously heating the anode or the cathode from room temperature to 200 °C; and

depositing a remaining of the light-emitting body composition on the anode or the cathode,

whereby forming a thin film having at least one layer structuring a light-emitting body.

10. A fabrication method of a light-emitting device characterized by comprising the steps of:

ejecting a solution containing a light-emitting body composition toward an anode provided on a substrate under a pressure lower than atmospheric pressure;

forming a thin film having at least one layer forming a light-emitting body by depositing the light-emitting body composition on the anode; and

forming a cathode on the light-emitting body by a sputtering method or an evaporation method after forming the thin film of the light-emitting body composition,

wherein the formation of the thin film having at least one layer forming the light-emitting body is performed by setting up the substrate with a substrate surface in a range of 0° to 30° relative to a horizontal plane, and by ejecting the solution containing the light-emitting body composition from the below of the substrate surface.

11. A fabrication method of a light-emitting device characterized by comprising the steps of:

ejecting a solution containing a light-emitting body composition toward an anode provided on a substrate under a pressure lower than atmospheric pressure;

depositing a remaining of the light-emitting body composition on the anode and volatilizing a solvent in the solution while the solution travels to the substrate, thereby forming a thin film having at least one layer forming a light-emitting body; and

forming a cathode on the light-emitting body by a sputtering method or an evaporation

method after forming the thin film of the light-emitting body composition,

wherein the formation of the thin film having at least one layer forming the light-emitting body is performed by setting up the substrate with a substrate surface in a range of 0° to 30° relative to a horizontal plane, and by ejecting the solution containing the light-emitting body composition from the below of the substrate surface.

12. A fabrication method of a light-emitting device characterized by comprising the steps of:

ejecting a solution containing a light-emitting body composition toward an anode provided on a substrate under a pressure lower than atmospheric pressure;

making a solvent in the solution start to volatilize simultaneously with an arrival thereof at the substrate by previously heating the substrate;

forming a thin film having at least one layer forming a light-emitting body by depositing a remaining of the light-emitting body composition on the anode; and

forming a cathode on the light-emitting body by a sputtering method or an evaporation method after forming the thin film of the light-emitting body composition,

wherein the formation of the thin film having at least one layer is performed by setting up the substrate with a substrate surface in a range of 0° to 30° relative to a horizontal plane, and by ejecting the solution containing the light-emitting body composition from the below of the substrate surface.

13. A fabrication method of a light-emitting device characterized by comprising the steps of:

ejecting a solution containing a light-emitting body composition toward an anode provided on a substrate under a pressure lower than atmospheric pressure;

making a solvent in the solution start to volatilize simultaneously with an arrival thereof at the substrate by previously heating the substrate from room temperature to 200 °C;

forming a thin film having at least one layer forming a light-emitting body by depositing a remaining of the light-emitting body composition on the anode; and

forming a cathode on the light-emitting body by a sputtering method or an evaporation method after forming the thin film of the light-emitting body composition,

wherein the formation of the thin film having at least one layer is performed by setting up the substrate with a substrate surface in a range of 0° to 30° relative to a horizontal plane, and by ejecting the solution containing the light-emitting body composition from the below of the

substrate surface.

14. A fabrication method of a light-emitting device according to any one of claims 10 to 13,

wherein the fabrication method of the light-emitting device is characterized in that each of the formations of the thin film having at least one layer forming the light-emitting body and the cathode is performed using a deposition apparatus of a multi-chamber scheme without exposure to the air.

15. A fabrication method of a light-emitting device according to any one of claims 10 to 13,

wherein the fabrication method of the light-emitting device is characterized in that each of the formations of the thin film having at least one layer forming the light-emitting body and the cathode is performed using a deposition apparatus of an in-line scheme without exposure to the air.

16. A fabrication method of a light-emitting device characterized by comprising the steps of:

ejecting a solution containing a light-emitting body composition toward a cathode provided on a substrate under a pressure lower than atmospheric pressure;

forming a thin film having at least one layer forming a light-emitting body by depositing the light-emitting body composition on the cathode; and

forming an anode on the light-emitting body by a sputtering method or an evaporation method after forming the thin film of the light-emitting body composition,

wherein the formation of the thin film having at least one layer forming the light-emitting body is performed by setting up the substrate with a substrate surface in a range of 0° to 30° relative to a horizontal plane, and by ejecting the solution containing the light-emitting body composition from the below of the substrate surface.

17. A fabrication method of a light-emitting device characterized by comprising the steps of:

ejecting a solution containing a light-emitting body composition toward a cathode provided on a substrate under a pressure lower than atmospheric pressure;

depositing a remaining of the light-emitting body composition on the cathode and

volatilizing a solvent in the solution while the solution travels to the substrate, thereby forming a thin film having at least one layer forming a light-emitting body; and

forming an anode on the light-emitting body by a sputtering method or an evaporation method after forming the thin film of the light-emitting body composition,

wherein the formation of the thin film having at least one layer forming the light-emitting body is performed by setting up the substrate with a substrate surface in a range of 0° to 30° relative to a horizontal plane, and by ejecting the solution containing the light-emitting body composition from the below of the substrate surface.

18. A fabrication method of a light-emitting device characterized by comprising the steps of:

ejecting a solution containing a light-emitting body composition toward a cathode provided on a substrate under a pressure lower than atmospheric pressure;

making a solvent in the solution start to volatilize simultaneously with an arrival thereof at the substrate by previously heating the substrate;

forming a thin film having at least one layer forming a light-emitting body by depositing a remaining of the light-emitting body composition on the cathode; and

forming an anode on the light-emitting body by a sputtering method or an evaporation method after forming the thin film of the light-emitting body composition,

wherein the formation of the thin film having at least one layer forming the light-emitting body is performed by setting up the substrate with a substrate surface in a range of 0° to 30° relative to a horizontal plane, and by ejecting the solution containing the light-emitting body composition from the below of the substrate surface.

19. A fabrication method of a light-emitting device characterized by comprising the steps of:

ejecting a solution containing a light-emitting body composition toward a cathode provided on a substrate under a pressure lower than atmospheric pressure;

making a solvent in the solution start to volatilize simultaneously with an arrival thereof at the substrate by previously heating the substrate from room temperature to 200 °C;

forming a thin film having at least one layer forming a light-emitting body by depositing a remaining of the light-emitting body composition on the cathode; and

forming an anode on the light-emitting body by a sputtering method or an evaporation method after forming the thin film of the light-emitting body composition,

wherein the formation of the thin film having at least one layer is performed by setting up the substrate with a substrate surface in a range of 0° to 30° relative to a horizontal plane, and by ejecting the solution containing the light-emitting body composition from the below of the substrate surface.

20. A fabrication method of a light-emitting device according to any one of claims 16 to 19,

wherein the fabrication method of a light-emitting device is characterized in that the formation of at least one layer of a thin film forming the light-emitting body is performed using a deposition apparatus of a multi-chamber scheme without exposure to the air.

21. A fabrication method of a light-emitting device according to any one of claims 16 to 19,

wherein the fabrication method of a light-emitting device is characterized in that the formation of at least one layer of a thin film forming the light-emitting body is performed using a deposition apparatus of an in-line scheme without exposure to the air.

22. A fabrication method of a light-emitting device according to any one of claims 1 to 21,

wherein the fabrication method of the light-emitting device is characterized in that under the pressure lower than atmospheric pressure is in an inert gas atmosphere at 1×10^3 to 1×10^5 Pa.

23. A fabrication method of a light-emitting device according to any one of claims 1 to 20,

wherein the fabrication method of the light-emitting device is characterized in that under the pressure lower than atmospheric pressure is in an inert gas atmosphere at 1×10^2 to 1×10^5 Pa.

24. A fabrication method of a light-emitting device according to any one of claims 1 to 23,

wherein the fabrication method of the light-emitting device is characterized in that the light-emitting body composition is intermittently deposited to form the thin film.

25. A fabrication method of a light-emitting device according to any one of claims 1 to 23,

wherein the fabrication method of the light-emitting device is characterized in that the light-emitting body composition is continuously deposited to form a thin film.

26. A fabrication method of a light-emitting device according to any one of claims 1 to 25,

wherein the fabrication method of the light-emitting device is characterized in that the solution containing the light-emitting body composition is ejected through a single or a plurality of nozzles.

27. A fabrication method of a light-emitting device according to any one of claims 1 to 26,

wherein the fabrication method of the light-emitting device is characterized in that the light-emitting body composition is a hole injection material, a hole transport material, a luminescent material, an electron transport material, an electron injection material, a hole blocking material, or an electron blocking material.

28. A fabrication method of a light-emitting device according to any one of claims 1 to 27,

wherein the fabrication method of the light-emitting device is characterized in that the thin film having at least one layer forming the light-emitting body is a thin film to function as a layer selected from a luminescent layer, a hole injection layer, a hole transport layer, a hole blocking layer, an electron injection layer, an electron transport layer, or an electron blocking layer.

29. A light-emitting device is characterized in that the light-emitting device is fabricated by a method according to any one of claims 1 to 13 and 16 to 19.

[Detailed Description of the Invention]

[0001]

[Technical Field to which the Invention Pertains]

The present invention belongs to a technical field related to a display device (hereinafter referred to as "light-emitting element") having, on a substrate, an element structured with an

anode, a cathode and a thin film which emits light by a phenomenon called electroluminescence (hereinafter referred to as "EL") which is sandwiched between the anode and the cathode, and to a technical field related to an electronics device having the light-emitting element in an image display portion.

[0002]

[Conventional Art]

A display for displaying an image is one of the light-emitting elements indispensable in modern living. The display for displaying an image takes a variety of forms matched to applications, ranging from so-called a television monitor to a liquid crystal display rapidly developed in recent years and an organic EL display expected for future development. In particular, a liquid crystal display and an organic EL display are light-emitting elements to be driven with a low voltage, which are the most important image displays from the viewpoint of energy saving.

[0003]

Among them, an organic EL display draws the greatest attentions as a flat panel display element for the next generation.

[0004]

In the emission mechanism of an organic EL display, a thin film (hereinafter referred to as "organic thin film") formed from a light-emitting body composition is provided between electrodes to flow current whereby the electrons injected from the cathode and the holes injected from the anode recombine at a luminescent center in a light-emitting body film and form a molecular exciton, to thereby utilize a photon released upon returning of the molecular exciton to the ground state.

[0005]

Incidentally, the sort of the molecular exciton formed by the light-emitting body composition can be a singlet excited state and a triplet excited state. The present specification includes a case where either one of the excited states contributes to light emission.

[0006]

In such an organic EL display element (hereinafter referred to as "organic EL element"), an organic thin film is usually formed as a film as thin as below 1 μm. In addition, because a light-emitting body film itself is a self-light-emitting type element which emits light, an organic EL element does not require a backlight as used in the conventional liquid-crystal display. Accordingly, it is a great merit that an organic EL element can be fabricated extremely thin and lightweight.

[0007]

Moreover, for example in an organic thin film of nearly 100 - 200 nm, the time of from a carrier injection up to recombination is approximately several ten nanoseconds in the light of the carrier mobility in the light-emitting body composition film. Light-emitting is caused on the order of within a microsecond even if the course of from a carrier recombination to light emission is included. Accordingly, very high-speed response is also one of features.

[0008]

Furthermore, because an organic EL element is a carrier-injection type light-emitting element, it can be driven on direct-current voltage, and hardly cause a noise. In addition, by forming a uniform ultra-thin organic thin film having nearly 100 nm in film thickness and using a suitable organic material, a driving is also possible on a voltage of several volts. Therefore, an organic EL element, because of a self-light-emitting type and a wide viewing angle, is well in visibility. Besides, an organic EL element also possesses the properties of being thin and lightweight, high-speed responsibility, driving in direct-current and low voltage, and the like, and thus is expected as a light-emitting element in the next generation.

[0009]

In order to fabricate such an organic EL element, there is an essential need of an art to form a thin film of a light-emitting body composition. In the liquid crystal display for example, in order to achieve a full-color display, there is a necessity to regularly form an organic thin film functioning as a color filter on a glass substrate. On the other hand, in an organic EL element, a charge transport material for transporting the holes and electrons injected at an electrode and a luminescent material for light-emitting formed of a light-emitting body composition. These compounds must be formed with a filmy form between electrodes.

[0010]

As techniques for forming such an organic thin film, various methods have been developed including a Langmuir-Blrogett method (LB method), a monomolecular film stack method, a dip coating method, a spin coating method, an inkjet method, a print method, an evaporation method, or the like. Among them, an inkjet method has particularly a merit that an organic material can be used with high-efficiency, the configuration of an apparatus is simple and can be reduced in size, and so on. Technically, it is already approximated to the practical application level. The basic technology concerning an inkjet method is disclosed in Patent Document 1, etc.

[0011]

An inkjet method is an art that an inkjet system employed for the conventional printer is

converted to a thin film formation, which is a method to apply droplets on a pixel to pixel basis by using, in place of ink, a solution or a dispersion liquid containing a light-emitting body composition as a material of an organic thin film. By volatilizing the solvent contained in the droplet, a thin film is formed on the individual pixel. By controlling the position of the droplet attached on a substrate, it is possible to form a given pattern.

[0012]

However, because the droplet attached on the pixel (actually, pixel electrode provided in each pixel) contains a great amount of solvent component, there is a need of a process for volatilizing a solvent component (hereinafter referred to as "baking process") in order to remove a solvent component. That is, after applying a droplet by an inkjet method, the entire pixel is sated to volatilize a solvent component and thereby the remaining solute (material of an organic thin film) forms with a thin film. Accordingly, in a case where the solvent of the solution containing a light-emitting body composition has a low vapor pressure, time is required in the baking process. Besides, droplets attached on the neighboring pixels are ready to mix together, and the formation of a microscopic thin film pattern is hindered. In addition, when a solvent component is left in the thin film, the solvent volatilizes with time and a degasification phenomenon is caused. Therefore, a factor incurring a deterioration in the organic thin film and ultimately a deterioration as a light-emitting element is caused. Furthermore, if the heating temperature is raised to remove the solvent component completely, it results in destruction in the composition of an organic thin film having a low heat resistance.

[0013]

In this manner, a formation method of the organic thin film based on an ink jet method is advantageous in low cost and simplicity. However, a formation method of the organic thin film based on the ink jet method has a problem in baking process; thus, it is an art left room for improvement.

[0014]

[Patent document 1] Japanese Patent Laid-Open No. H10-12377

[0015]

[Problems to be Solved by the Invention]

The present invention has been made in view of the above problem, and it is an object of the present invention is to provide a technology for omitting a baking process in an approach of forming an organic thin film by applying a solution. Furthermore, it is an object to provide a manufacturing method of a light-emitting device with high throughput with low cost and a simple method by applying the present art to manufacture a light-emitting device.

[0016]

[Means to Solve the Problems]

The present invention is a manufacturing method of a light-emitting device, characterized by spraying a solution containing a light-emitting body composition toward a pixel electrode (anode or cathode) under reduced pressure, and specifically 1×10^2 - 1×10^5 Pa, preferably 10 - 2×10^4 Pa to deposit the light-emitting body composition on the pixel electrode, thereby forming a thin film having at least one layer. At this time, in the duration before the solution reaches the pixel electrode, the solvent in the solution may be volatilized and the remaining of the light-emitting body composition may be deposited on the pixel electrode, and thereby an organic thin film having one layer may be formed. Furthermore, by previously heating the pixel electrode (preferably at room temperature (typically 20 °C) – 300 °C, further preferably 50 – 200 °C, considering the heat resistance of the light-emitting body composition), the solvent in the solution may be commenced to volatilize simultaneously with an arrival of the solution at the pixel electrode, to deposit the remaining of the light-emitting body composition on the pixel electrode, and thereby an organic thin film having at least one layer may be formed. In any event, the present invention is characterized in that a solvent component is volatilized simultaneously with forming an organic thin film having at least one layer, and thereby the baking process required in the conventional process is eliminated or shorten.

[0017]

In the present invention, a light-emitting body refers to a carrier injection material (hole injection material or electron injection material), a carrier transport material (hole transport material or electron transport material), a carrier blocking material (hole blocking material or electron blocking material), a luminescent material or another organic compound or inorganic compound which contributes to carrier recombination, and a laminated body thereof. In addition, a light-emitting body composition refers to a composition usable as a material of those light-emitting bodies, irrespective of organic compound or inorganic compound. The light-emitting body composition roughly includes a luminescent material and a carrier (hole or electron) transport material.

[0018]

The luminescent material is a material that causes photoluminescence due to EL by injecting holes or electrons. Such a luminescent material is found in inorganic compounds and organic compounds. The method of applying a solution as in the present invention preferably uses an organic compound. In addition, the luminescent material may use a material to cause fluorescence based on singlet excitation or a material to cause phosphorescence based on triplet

excitation. Moreover, the hole transport material is a material allowing holes to readily move while the electron transport material is a material allowing electrons to readily move.

[0019]

The pressure lower than the atmospheric pressure may be given as 1×10^3 - 1×10^5 Pa in an atmosphere filled with an inert gas such as nitrogen or rare gas (also referred to as inert atmosphere), and 1×10^2 - 1×10^5 Pa under a reduced pressure. When placed under a reduced pressure (also called in vacuum), until the droplet ejected to the atmosphere reaches the pixel electrode, the solvent in the droplet incessantly volatilizes from the droplet, and thus the volume of the droplet is being reduced. At the time of an arrival at the pixel electrode, nearly all the part of the solvent vaporizes, so that film formation is completed simultaneously with the arrival. Namely, there is excellence over the conventional art in that there is no need of a heating process, such as a baking process, after solution application.

[0020]

In addition, in order to sufficiently volatilize the solvent before the arrival at the pixel electrode, it is preferred to use a highly volatile solvent (i.e. solvent high in vapor pressure) as a solvent. This is because, with low volatility, there is a need to increase the time required for volatilization by increasing the distance between the pixel electrode and an injection opening for the solution (nozzle tip), and when the distance is long, the trajectory error between droplets is increased. Highly volatile solvents include alcohols such as methanol and ethanol.

[0021]

In addition, in the case where a solvent having a high melting point is used without using a solvent high in volatility, it is possible to eliminate the anxiety, e.g. clogging occurrence at the nozzle tip due to drying of droplets at the injection opening. In such a case, in the case where the pixel electrode is previously heated (at room temperature (typically 20 °C) to 300 °C, further preferably 50 to 200 °C, in consideration of heat resistance of the light-emitting body), volatilization begins together with an arrival of the droplet at the pixel electrode, and it is possible to complete a baking process simultaneously with ejection of a droplet to another pixel. Of course, by the above method, film quality can be further improved by volatilizing the solvent from the droplet until the droplet reaches the pixel electrode and further by previously heating the pixel electrode.

[0022]

The above solvent high in melting point can use NMP (N-methylpyrrolidone), DMF (dimethyl formamide), DMSO (dimethyl sulfoxide), HMPA (hexamethylphosphoramide) or other polar solvents. In addition, the solvent low in polarity may use aromatic solvents like

alkylbenzene (particularly, long-chain alkylbenzene like dodecylbenzene is preferred) such as xylene. For example, it is possible to use a solvent mixing Tetralin and dodecylbenzene by 1 : 1.

[0023]

Incidentally, the present invention can be carried out in fabricating a passive matrix type light-emitting device and in fabricating an active-matrix type light-emitting device, and therefore the present invention is not especially limited to a light-emitting device mode. In addition, the luminescent material is also applicable to an inorganic compound without limitation to an organic compound. Moreover, the substrate to be processed can use paper, a polymer membrane, an inorganic oxide plate including glass, an indium-tin oxide (ITO) film, or the like without limitation. In particular, in the case of carrying out the present invention, there is no especial need of a baking process after solution application, and thereby the present invention is effective in laminating organic compounds.

[0024]

[Mode for Carrying Out the Invention]

(Embodiment Mode 1)

Embodiment modes of the present invention is explained using FIG. 1. FIG. 1(A) represents a state immediately after ejecting a solution containing a luminescent material. FIG. 1(B) represents a state where the luminescent material has reached an anode or a cathode so as to form a thin film (light-emitting layer). Incidentally, the figure shows a manner that the substrate is provided in parallel with respect to the horizontal plane and a light-emitting body is ejected from the bottom of the substrate.

[0025]

In FIG. 1(A), 101 is an anode or a cathode, 102 is an insulator defining each pixel, and 103 is a carrier injection layer. The carrier injection layer 103 is a hole injection layer provided that 101 is an anode, or an electron injection layer provided that 101 is a cathode. In addition, 104 is a magnification of a head in a device for applying a solution (hereinafter, referred to as a solution applying device), which partially shows an internal structure. The head 104 has a plurality of ejector parts 105a - 105c having a function to eject a solution containing a luminescent material, which are provided with piezoelectric elements (piezo elements) 106a - 106c, respectively. Moreover, the ejector parts 105a - 105c are filled with solutions 107a - 107c containing luminescent materials, respectively.

[0026]

Here, the solution 107a containing a luminescent material includes a luminescent

material which causes light emission in red, the solution 107b containing a luminescent material includes a luminescent material which causes light emission in green, and the solution 107c containing a luminescent material includes a luminescent material which causes light emission in blue. These three kinds of luminescent materials constitute a pixel which causes light emission in red, a pixel which causes light emission in green and a pixel which causes light emission in blue, respectively. These three pixels are grasped as one pixel unit.

[0027]

Incidentally, although FIG. 1(A) explains only one ejector part corresponding to each of R (red), G (green), and B (blue), respectively, a plurality of ejector parts (nozzles) can be arranged in parallel. Taking throughput into consideration, it can be considered the most desirable to arrange the number of ejector parts corresponding to the number of pixels (pixel count) on one row or one column of a pixel portion.

[0028]

In addition, the most characteristic point in the present invention lies in that a space 108 between the head 104 and the anode or the cathode 101 is sustained at a reduced pressure, i.e. at a pressure lower than the atmospheric pressure. Specifically, this is at 1×10^3 - 1×10^5 Pa in an inert atmosphere. The solutions 107a - 107c containing a luminescent material filled in the ejector parts 105a - 105c are pressurized and pushed out by alteration in volume of the piezoelectric elements 106a - 106c and ejected toward the pixel electrode 101. Then, an ejected droplet 109 travels while the solvent is volatilized under the reduced pressure so that the remaining luminescent material is deposited on the pixel electrode 101. As a result, the luminescent material is deposited intermittently.

[0029]

Thus, a thin film deposited is formed to a thin film in a state where a solvent component is fully removed without especially volatilizing the solvent by the means of heating or the like. Accordingly, it is possible to obtain a light-emitting layer with fewer problems such as deterioration with time due to degasification. With the structure as above, a baking process or the like is not required even after applying the solution, and it is possible to greatly improve throughput and prevent the luminescent material itself from deteriorating due to heating. Incidentally, although the present invention is characterized in that baking process is not needed, if baking process such as a heating process under a reduced pressure is used together, the advantageous effect of the present invention of obtaining a light-emitting layer in which a solvent component is fully removed and degasification hardly occurs is not spoiled.

[0030]

In this manner, a light-emitting layer 110a which emits light in red, a light-emitting layer 110b which emits light in green, and a light-emitting layer 110c which emits light in blue are formed, as shown in FIG. 1(B). After that, when a counter electrode (a cathode for an anode, an anode for a cathode) is provided after forming a carrier transport layer, a carrier injection layer and the like, if necessary, and then a light-emitting element is completed.

[0031]

(Embodiment Mode 2)

The present Embodiment Mode is an example of applying a gel solution having a certain degree of viscosity instead of applying a solution by ejecting droplets. FIG. 2(A) represents a state where a solution containing a luminescent material is being ejected while FIG. 2(B) represents a state where the solution containing a luminescent material is ceased from ejecting. Incidentally, this figure shows a state where the substrate is provided in parallel with respect to the horizontal plane and a light-emitting body is being ejected from the below of the substrate. In addition, the same reference numerals as those used in FIG. 1 may be referred to the explanation of Embodiment Mode 1.

[0032]

The present Embodiment Mode has a plurality of ejector parts 205a - 205c having functions to eject luminescent materials, respectively, in a head 204 of a solution applying device as shown in FIG. 2(A), and the ejector parts 205a - 205c are provided with piezoelectric elements (piezo resistance elements) 206a - 206c, respectively. In addition, the ejector parts 205a - 205c are filled with solutions 207a -207c containing luminescent materials, respectively. At this time, similarly to FIG. 1(A), the solution 207a containing a luminescent material includes a luminescent material which causes light emission in red, the solution 207b containing a luminescent material includes a luminescent material which causes light emission in green, and the solution 207c containing a luminescent material includes a luminescent material which causes light emission in blue.

[0033]

However, in the present Embodiment Mode, the viscosity of the solutions 207a - 207c containing a luminescent material is adjusted higher than the viscosity of the solutions 107a - 107c containing a luminescent material of Embodiment Mode 1. This is to apply the solution containing a luminescent material continuously. As a result, the luminescent material is deposited continuously. In addition, as shown in FIG. 2(A), when applying the solutions 207a - 207c containing a luminescent material, the solutions 207a - 207c containing a luminescent material are applied by being pressurized and pushed out by an inert gas such as nitrogen in a

state where the piezoelectric elements 206a - 206c are pushed down.

[0034]

Incidentally, the solvent in the solutions 207a - 207c containing a luminescent material begins to volatilize immediately after the solutions come out of the injection opening so as to reach a pixel electrode 101 while being gradually reduced in volume. By the time the solution reaches onto the pixel electrode 101, the solvent in the major part is volatilized and the remaining luminescent material is deposited to form a light-emitting layer. Of course, the atmosphere within the space 108 is sustained at a reduced pressure similar to Embodiment Mode 1.

[0035]

In addition, as shown in FIG. 2(B), when the application of the solutions 207a - 207c containing a luminescent material ceases, the pressurization by the inert gas is stopped and the piezoelectric elements 206a - 206c are put in a state pushed up (in the direction of the arrows). By doing so, the solution containing a luminescent material is retracted to somewhat deep from the injection opening, and thereby it is possible to prevent the solution from drying.

[0036]

Furthermore, at this time, by placing the space 108 with a solvent atmosphere, the solutions 207a - 207c containing a luminescent material can be prevented from drying at the injection opening. In addition, although the present Embodiment Mode showed the example that the solution is introduced into the injection opening by the use of the piezoelectric elements 206a - 206c, this can be similarly made by putting the space 108 in a pressurized state.

[0037]

In this manner, a light-emitting layer 210a which emits light in red, a light-emitting layer 210b which emits light in green and a light-emitting layer 210c which emits light in blue are formed, as shown in FIG. 2(B). Thus, because the light-emitting layer formed becomes a thin film in a state where a solvent component is fully removed without especially volatilizing the solvent by the means of heating or the like, it is possible to obtain a light-emitting layer with fewer problems of deterioration with time due to degasification. Even after applying the solvent with the above structure, there is no need for a baking process and the like, and it is possible to greatly improve throughput and to prevent the luminescent material itself from deteriorating due to heating.

[0038]

Incidentally, although the present invention is characterized in that a baking process is not required, if a baking process such as a heating process under a reduced pressure is

performed together, the advantageous effect of the present invention of obtaining a light-emitting layer in which a solvent component is fully removed and degasification hardly occurs is not spoiled. In addition, after that, a counter electrode (a cathode for an anode, an anode for a cathode) is provided after forming a carrier transport layer, a carrier injection layer and the like as necessary, and thereby completing a light-emitting element.

[0039]

In addition, the present invention can be carried out in manufacturing a passive-matrix type light-emitting device and in manufacturing an active-matrix type light-emitting device, and thus the present invention is not limited to the form of a light-emitting device. Moreover, with respect to a luminescent material, the present invention can be implemented not only when an organic compound is used but also when an inorganic compound is used. In particular, it is advantageous to carry out the present invention in the case where organic compounds are stacked, because a baking process is not especially required after applying a solution.

[0040]

(Embodiment Mode 3)

The present Embodiment Mode is explained by using FIG. 3. FIG. 3(A) represents a state where a solution containing a luminescent material is ejected, and the droplet thereof reaches an anode or a cathode hereupon. FIG. 3(B) represents a state where a luminescent material is baked over the anode or a cathode to thereby form a thin film (light-emitting layer). This figure shows a manner that the substrate is provided in parallel with respect to the horizontal plane wherein a light-emitting body is by ejection from the below of the substrate. Incidentally, the solution-applying device in FIG. 3 is the same as that explained in FIG. 1. The parts having the same reference numerals as those used in FIG. 1 may be referred to the explanation in Embodiment Mode 1.

[0041]

In FIG. 3(A), the ejector parts 105a - 105c having piezoelectric elements (piezo elements) 106a - 106c are filled with solutions 307a - 307c containing luminescent materials, respectively. The solutions 307a - 307c containing a luminescent material uses, as a solute, a luminescent material which emits light in red, green or blue, and, as a solvent, a solvent having a high boiling point (note, which preferably volatilizes at room temperature (typically 20 °C) to 300 °C, more preferably at 50 to 200 °C). For this reason, the solutions 307a - 307c containing a luminescent material becomes solutions which dries very hardly.

[0042]

The solutions 307a - 307c containing luminescent materials are pushed out by the

piezoelectric elements 106a - 106c and ejected through a plurality of ejector parts 105a - 105c. The liquid deposit in a state immediately after arrival on the anode or the cathode 101 is denoted by 309. Of course, the space 108 between the head 104 and the anode or the cathode 101 is sustained at a reduced pressure, i.e. at a pressure lower than the atmospheric pressure. Specifically, it is at 1×10^3 - 1×10^5 Pa in an inert atmosphere.

[0043]

At this time, the anode or the cathode 101 is heated at room temperature (typically 20 °C) to 300 °C, further preferably 50 to 200 °C. The solvent in the liquid deposit 309 begins to volatilize immediately after the deposit reaches the anode or the cathode 101. Incidentally, FIG. 3(A) explains only the pixels of one line. However, the actual pixel region is provided with a plurality of lines of pixels in juxtaposition so that the solutions 307a - 307c containing luminescent materials are sequentially ejected onto the pixels. Accordingly, a certain time is required in the application throughout the entire pixels. The present Embodiment Mode is introduced to complete a baking process by making use of such a certain time.

[0044]

The thin film thus deposited is nearly completed in a baking process at the time the application over the entire pixel region is ended. Despite carrying out a baking process, process time can be greatly shortened as compared to a conventional approach. In this manner, a light-emitting layer 310a which emits light in red, a light-emitting layer 310b which emits light in green, and a light-emitting layer 310c which emits light in blue are formed, as shown in FIG. 3(B). In addition, after that, when a counter electrode (a cathode for an anode, an anode for a cathode) is provided after forming a carrier transport layer, a carrier injection layer, and the like as necessary, thereby completing a light-emitting element.

[0045]

Incidentally, the structure of this embodiment mode in which the whole of the pixel region to be a formation region is heated up while applying a solution by an inkjet scheme by the use of a solution containing a luminescent material using a solvent high in boiling point can have the same advantageous effect when applied to the solution applying device of the structure of not only Embodiment Mode 1 but also of Embodiment Mode 2 in addition to that of this embodiment mode.

[0046]

(Embodiment Mode 4)

The present embodiment mode explains an art for filling a light-emitting body composition without exposure to the air during filling a solution containing a light-emitting

body composition to the head shown in Embodiment Mode 1 and Embodiment Mode 2.

[0047]

FIG. 4 shows a cross-sectional view of a vessel (canister can) for reserving (stocking) a solution containing a light-emitting body composition in a solution-applying device. A vessel 351 is desirably formed of a material having a sufficient resistance to secrecy, particularly, transmission of oxygen or moisture. It preferably uses stainless steel, aluminum or the like. In addition, the inner surface is desirably mirror finished. Furthermore, the inner surface and/or the outer surface may be provided, as required, with an insulating film low in oxygen transmittance of a silicon nitride film, diamond-like carbon film or the like. This is for preventing against deterioration of a solution 352 containing a light-emitting body composition provided within the vessel 351.

[0048]

In addition, 353 is an introduction port for introducing an inert gas of nitrogen, a rare gas, or the like into the vessel 351, through which an inert gas is introduced to pressurize the in-vessel pressure. In addition, 354 is an exit port to feed the solution 352 containing a light-emitting body composition delivered by pressurization to the head of the solution-applying device (not shown). The introduction port 353 and the exit port 354 may be formed of a different material from the vessel 351 or integrally formed therewith.

[0049]

Incidentally, 356 is an introduction tube for coupling to the introduction port 353. When actually introducing an inert gas, the tip of the introduction tube 356 is connected to the introduction port 353 to thereby introduce the inert gas. Similarly, the tip of the exit tube 357 is coupled to the exit port 354, to allow the solution 352 containing a light-emitting body composition to exit. In the figure, they are removable and hence shown by the dotted lines.

[0050]

Each of head shown in Embodiment Mode 1 and Embodiment Mode 2 is attached at an extended tip of the exit tube 357. In the case of Embodiment Mode 1, by vibrating the piezoelectric elements 106a - 106c in a state where the inside of the vessel 351 is pressurized by the inert gas, the solution 352 containing a light-emitting body composition can be ejected intermittently. In addition, in the case of Embodiment Mode 2, continuous application is possible while pressuring the inside of the vessel 351 by the inert gas within. When pressurization is ceased, ejection of the solution 352 containing a light-emitting body composition is stopped.

[0051]

Furthermore, the present embodiment mode is characterized in that, in the duration of from placing the solution 352 containing a light-emitting body composition into the vessel 351 up to an attachment to the solution-applying device, it is transported while shielded from the air. Specifically, the maker who manufacturers the solution 352 containing a light-emitting body composition is permitted to place a solution 352 containing a light-emitting body composition into the vessel 351, transport it while keeping air-tightness without exposure to the air, and attach it directly onto the solution applying device. This is a devising made in view of the fact that the light-emitting body composition is low in resistance to oxygen or moisture and ready to deteriorate. Because of the capability of keeping the purity of refinement as it is in the duration of after refining the light-emitting body composition and before application, it contributes to suppression against deterioration in the light-emitting body composition and ultimately to improvement in the reliability of the light-emitting device.

[0052]

Incidentally, the vessel shown in FIG. 4 in the present embodiment mode is a suitable one example for transporting a solution containing a light-emitting body composition while keeping the purity thereof, which does not limit the vessels which can be used for the present invention.

[0053]

(Embodiment Mode 5)

The present embodiment mode is characterized in that a longer wavelength region of light is used upon heating the pixel region entirely in Embodiment Mode 3. The structure of the present embodiment is explained using FIGS. 5(A) - (C). Incidentally, FIG. 5(A) is a view of the substrate as viewed from the below when the substrate is heated up in the present embodiment mode. FIG. 5(B) is a cross-sectional view along A-A' therein, and FIG. 5(C) is a cross-sectional view along B-B' therein.

[0054]

In FIG. 5(A), 601 is a substrate which transmits at least a longer wavelength of light (typically, a longer wavelength of light than a wavelength 300 nm) than a visible portion of light, on which thin film transistors, pixel electrodes and the like are provided. The substrate 601 is transported in a direction of an arrow 602 by a transport mechanism not shown.

[0055]

In addition, a head 603 of a solution-applying device is provided underneath a surface to be processed of the substrate 601, to apply a solution containing a light-emitting body composition in the form explained in Embodiment Modes 1 - 3. A light-emitting body

composition 604 applied is heated by the light (hereinafter, referred to as lamp light) emitted from a lamp 605 set up above a backside of the substrate 601, and made into a light-emitting body 606 by volatilization of solvent (being baked). Specifically, the applied light-emitting body composition 604, after application, is baked sequentially by lamp light and made into a thin film.

[0056]

Specifically, by moving the substrate 601, the head 603 and the lamp 605 is scanned in a direction relatively reverse to the moving direction of the substrate 601. Of course, the substrate 601 can be fixed to scan the head 603 and the lamp 605. In this case, the head 603 is structurally earlier to be scanned at all times. As a result, solution application by the head 603 and the next baking process using lamp light are performed almost simultaneously; thus, an effect equal to the case of omitting the baking process can be obtained substantially.

[0057]

Incidentally, the light can be used as lamp light is a wavelength of light capable of heating only without destructing the composition of the light-emitting body 606. Specifically, it is preferably a longer wavelength of light than 400 nm, i.e. a longer wavelength of light than infrared light. For example, it can use an electromagnetic wave in a wavelength region of 1 μm - 10 cm from a far-infrared ray to a microwave. In particular, a far-infrared ray (typically a wavelength of 4 - 25 μm) is preferably used in view of handling.

[0058]

In addition, although the example was herein shown in which entire-surface application is completed simply by once scanning of the head 603, the substrate 601 may be reciprocated several times to perform repeated applications a plurality of number of times, and then the scanning of the lamp 605 may be performed. At this time, the lamp 605 may be put off during the scanning of the head 603 in first few times. In synchronism with the last scanning of the head 603, scanning and light emission may be made with the lamp 605.

[0059]

As above, by irradiation with a longer wavelength than far-infrared region of light by the use of a light source such as a lamp as heating means in a baking process, application and baking of a light-emitting body composition can be carried out almost simultaneously. This can provide a process in which a baking process is substantially omitted. This can improve the throughput in a manufacturing process of a light-emitting device.

[0060]

(Embodiment Mode 6)

The present embodiment mode is characterized in that a Roll-to-Roll scheme is employed in Embodiment Mode 5. Specifically, as shown in FIG. 6(A), a flexible substrate such as a polymer film is previously formed in a strip form and rolled up in a cylindrical form. In FIG. 6(A), thin film transistors, pixel electrodes, and the like are previously provided on a rolled-up flexible substrate 20. The substrate 21 is led out in a direction of an arrow 22 from a tip and again rolled up into a cylindrical core, and thus the substrate 21 is formed. FIG. 6(B) is a view of the present device as viewed from the below. The substrate 21 rolled up is led out in the direction of the arrow 23 and again rolled up to form a rolled substrate 21.

[0061]

By leading out the substrate 20 from the tip, the substrate is exposed. The head 603 of a solution-applying device is set up below an exposed portion 23, to apply a solution containing a light-emitting body composition in the form explained in Embodiment Modes 1 - 3. Incidentally, a plurality of the heads can be provided in the solution-applying device. The applied light-emitting body composition 604 is heated by the lamp light from the lamp 605 set up above the exposed portion 23 of the substrate, and a solvent is volatilized (baked) to be a light-emitting body 606. As a result, solution application by the head 603 and the subsequent baking process using lamp light can be performed almost simultaneously.

[0062]

In addition, because a solution containing a light-emitting body composition can be applied almost continuously, it is easy to prevent the nozzle from drying. Furthermore, because the substrate can be provided in a rolled up form, solution application and a baking process can be achieved almost simultaneously, and therefore the exposed portion 23 of the substrate can be decreased in area. Because the substrate in which baking has been completed can be immediately rolled up in a rolled form, the throughput of the light-emitting device in a manufacturing process can be improved. Besides, size reduction and space saving of the light-emitting device can be achieved at the same time.

(Embodiment Mode 7)

The light-emitting body shown in Embodiment Modes 1 - 5 includes a light-emitting layer, a hole injection layer, a hole transport layer, a hole blocking layer, an electron injection layer, and an electron transport layer or an electron blocking layer or a laminate thereof. These may be structured with only organic compounds or with a composite in which an organic compound and an inorganic compound are stacked.

[0063]

Accordingly, the present embodiment mode explains an example of using a composite

in which organic and inorganic compounds are combined as a light-emitting body for a light-emitting device of the present invention. Incidentally, there is U.S. Patent No. 5,895,932 which is a patent characterized in a hybrid structure in which organic and inorganic compounds are stacked. The patent is an art that extracts light caused by a phenomenon called photoluminescence by irradiating Alq_3 (tris-8-quinolinolato aluminum complex) as an organic compound with ultraviolet light (wavelength: 380 nm) emitted from a diode formed of an inorganic compound. This is a technical idea basically different from the light-emitting body explained in the present embodiment mode, i.e. composite.

[0064]

Among organic compounds, polymeric organic compounds (hereinafter, referred to as organic polymers) are high in heat resistance and easy to handle, and hence used as solutes in the film formation methods with solution application. The present embodiment mode explains a case of using a composite of an organic polymer and an inorganic compound as a light-emitting body.

[0065]

The examples of forming a light-emitting body by stacking an organic polymer and an inorganic compound typically include the following four patterns:

(a) a combination of a hole injection layer (or hole transport layer) of an inorganic compound and a light-emitting layer of an organic polymer,

(b) a combination of an electron injection layer (or electron transport layer) of an inorganic compound and a light-emitting layer of an organic polymer,

(c) a combination of a light-emitting layer of an inorganic compound and a hole injection layer (or hole transport layer) of an organic polymer, and

(d) a combination of a light-emitting layer of an inorganic compound and an electron injection layer (or electron transport layer) of an organic polymer.

[0066]

In addition, the examples of forming a light-emitting body by mixing an organic polymer and an inorganic compound typically include the following three patterns:

(e) a combination in which an organic polymer having a carrier transportability is provided as a light-emitting layer, and an inorganic compound is mixed in the organic polymer,

(f) a combination in which as a light-emitting layer, an organic polymer and inorganic compound having the same conductivity (n-type or p-type) of carrier transportability are mixed, and

(g) a combination in which an organic polymer having a carrier transportability is mixed

with an inorganic compound having a carrier acceptability.

[0067]

The above structure (g) includes a combination, for example, of an organic polymer having a hole transportability mixed with an inorganic compound having an electron acceptability. In this case, the inorganic compound having electron acceptability has a structure in which the inorganic compound receives electrons from the organic polymer and, as a result, holes are generated in the organic polymer and furthermore the holes are transported to obtain transportability.

[0068]

In the above structures (a) - (g), the hole injection layer or the hole transport layer formed of an inorganic compound can use a p-type semiconductor material such as NiO (nickel oxide). The electron injection layer or the electron transport layer formed of an inorganic compound can use an n-type semiconductor material such as ZnO (zinc oxide) or TiO_2 (titanium dioxide). The light-emitting layer formed of an inorganic compound can use such as ZnS (zinc sulfide) or CdS (cadmium sulfide).

[0069]

For example, the example of the above structure (b) includes an example of using PPV (polyparaphenylene vinylene) as an organic polymer and CdS as an inorganic compound, and manufacturing these by solution application. In this case, in forming CdS, a nano-fine particle (refers to and hereinafter will refer to a particle of several nm to several tens nm) of CdS can be dispersed in a solvent and applied. The application process of the present invention may be carried out to this application process. Incidentally, in place of Cds, an n-type semiconductor material of ZnO, TiO_2 or the like or a p-type semiconductor material of NiO or the like may be used. In addition, a conjugated polymer such as a polyacetylene derivative, a polythiophene derivative, a polyphenyleneethynylene derivative, a polyvinyl carbazole derivative, a polyfluorene derivative, or a polysilanes may be used as the organic polymer.

[0070]

The example of the above structure (e) includes an example using PVK (polyvinyl carbazole) as an organic polymer and CdS as an inorganic compound and manufacturing these by solution application. In this case, light emission takes place with CdS as a luminescent center. In forming CdS, a CdS particle can be dispersed in a solvent and applied. The application process of the present invention may be implemented in this application process. Incidentally, in place of Cds, an inorganic compound such as ZnS can be used. Because inorganic compounds easily form a nano-fine particle, these CdS and ZnS are quite suitable

materials in the case where solution application is premised as in the present invention.

[0071]

In addition, the example of the above structure (g) uses PC (polycarbonate) as an organic polymer, and the PC is mixed with TPD (triphenyl diamine) as a hole transportable inorganic compound and alkoxide of Ti to perform solution application, and then to form a light-emitting body mixed with PC, TPD, and TiO_2 by hydrolysis and heating under a reduced pressure. In this case, in forming CdS, CdS particles can be dispersed in a solvent and applied. The application process of the present invention may be implemented in this application process.

[0072]

As above, a composite light-emitting body (composite) can be fabricated by the use of various organic and inorganic compounds. In addition, in the formation thereof, the fabrication method of the present invention can be implemented.

[0073]

Incidentally, the structure of a light-emitting body (composite) shown in the present embodiment mode can be fabricated using any of the methods in Embodiment Modes 1 - 3 and 5. The composite can also be preserved in the vessel shown in Embodiment Mode 4.

[0074]

(Embodiment Mode 8)

The present embodiment mode explains one example of a light-emitting device which can be fabricated by carrying out the present invention with reference to FIG. 7. In a pixel structure shown in FIG. 7(A), 401 is a data signal line, 402 is a gate signal line, 403 is a power source line, 404 is a switching thin film transistor (referred to as and hereinafter referred to as a switching TFT), 405 is a capacitor for holding charge, 406 is a driving thin film transistor (referred to and hereinafter referred to as a driving TFT) for supplying current to the light-emitting device, 407 is a pixel electrode connected to a drain of the driving TFT, and the pixel electrode 407 functions as an anode of the light-emitting device. In addition, 412 is a counter electrode. The counter electrode 412 functions as a cathode of a light-emitting device.

[0075]

FIG. 7(B) shows a figure corresponding to a section on A-A' at this time. In FIG. 6(B), 410 is a substrate that can use a transparent substrate of a glass substrate, a quartz substrate, a plastic substrate, or the like. The driving TFT 406 is formed on the substrate 410 by the use of a semiconductor process. In addition, an insulator 408 patterned in a grating form is provided so as to cover an end of the pixel electrode 407 formed and to be connected to the driving TFT 406 and at least the driving TFT and a switching TFT.

[0076]

On these pixel electrodes 407, light-emitting bodies 411a - 411c, a counter electrode 412 functioning as a cathode and a passivation film 413 are provided. The light-emitting bodies 411a - 411c each refer to an organic compound, an inorganic compound, or a laminate thereof, which contributes to carrier recombination in a carrier injection layer, a carrier transport layer, a carrier blocking layer, a light-emitting layer, or the like. The layered structure and material of the light-emitting bodies 411a - 411c may each use a known structure and material.

[0077]

For example, an inorganic hole injection layer (or may be referred to as an inorganic hole transport layer) high in resistance (resistivity: $1 - 1 \times 10^{11}\ \Omega \cdot cm$) may be included as at least one layer of the light-emitting body as described in Japanese Patent Laid-open No. 2000-268967, Japanese Patent Laid-open No. 2000-294375, etc. The inorganic hole injection layer contains, as a first component, an alkali metal element selected from Li, Na, K, Rb, Cs, or Fr, an alkaline-earth metal element selected from Mg, Ca, or Sr or a lanthanide-based element selected from La or Ce, and as a second component, an element selected from Zn, Sn, V, Ru, Sm, or In. In addition, an inorganic electron transport layer high in resistance (resistivity: $1 - 1 \times 10^{11}\ \Omega \cdot cm$) may be included in at least one layer of the light-emitting body. The inorganic hole injection layer contains a metal element selected from Au, Cu, Fe, Ni, Ru, Sn, Cr, Ir, Nb, Pt, W, Mo, Ta, Pd, or Co; or an oxide, an carbide, a nitride, a silicide, or a boride thereof. In addition, the inorganic hole injection layer may contain an oxide of silicon, germanium or silicon germanium as a main component. By using a stable inorganic insulating film in a part of the light-emitting body, reliability of a light-emitting device can be enhanced.

[0078]

In addition, the counter electrode 412 can use an aluminum film or a silver thin film containing an element belonging to group 1 or 2 of the periodic table. However, in the case of the present embodiment mode, because of the necessity to transmit the light emitted from the light-emitting bodies 411a - 411c, the film thickness is desirably 50 nm or less. Moreover, the passivation film 413 can use an insulating film exhibiting high blockability against moisture and oxygen, such as a silicon nitride film, an aluminum nitride film, a diamond-like carbon film, or the like.

[0079]

In fabricating a light-emitting device of the above structure, implementing the present invention makes it possible to produce a light-emitting device high in throughput by a simple method at a low cost. Furthermore, the reliability of the light-emitting device can also be

improved.

[0080]

(Embodiment Mode 9)

The present embodiment mode explains one example of a light-emitting device that can be fabricated by carrying out the present invention with reference to FIG. 8. In a pixel structure shown in FIG. 8(A), 501 is a data signal line, 502 is a gate signal line, 503 is a power source line, 504 is a switching TFT, 505 is a capacitor for holding charge, 506 is a driving TFT, 507 is a drain electrode of the driving TFT, and 508 is a pixel electrode connected to the drain of the driving TFT, and the pixel electrode 508 functions as an anode of the light-emitting device. This pixel electrode 508 preferably uses a conductor film transparent to visible light so that the light emitted from the light-emitting body can be transmitted. It preferably uses an oxide conductor film such as ITO (compound of indium oxide and tin oxide) or a compound of indium oxide and zinc oxide. 512 is a counter electrode. The counter electrode 512 functions as a cathode of the light-emitting device.

[0081]

FIG. 8(B) is a figure corresponding to a cross section on A-A' at this time. In FIG. 8(B), 510 is a substrate that can use a transparent substrate of a glass substrate, a quartz substrate, a plastic substrate, or the like. The driving TFT 506 is formed on the substrate 510 by the use of a semiconductor process. In addition, an insulator 509 patterned in a grating form is formed to cover an end of the pixel electrode 508 and to be connected to the driving TFT 506 and at least the driving TFT and a switching TFT.

[0082]

On these pixel electrodes 508, light-emitting bodies 511a - 511c, a counter electrode 512 to function as a cathode, and a passivation film 513 are provided. The light-emitting bodies 511a - 511c each refer to an organic compound, inorganic compound or a laminate thereof, which contributes to carrier recombination in a carrier injection layer, a carrier transport layer, a carrier blocking layer, a light-emitting layer, or the like. The layered structure and material of the light-emitting bodies 511a - 511c may each use a known structure and material.

[0083]

For example, an inorganic hole injection layer (or may be referred to as an inorganic hole transport layer) high in resistance (resistivity: $1 - 1 \times 10^{11}\ \Omega \cdot \mathrm{cm}$) may be included as at least one layer of the light-emitting body as described in Japanese Patent Laid-open No. 2000-268967, Japanese Patent Laid-open No. 2000-294375, etc. The inorganic hole injection layer contains, as a first component, an alkali metal element selected from Li, Na, K, Rb, Cs, or

Fr, an alkaline-earth metal element selected from Mg, Ca, or Sr or a lanthanide-based element selected from La or Ce, and as a second component, an element selected from Zn, Sn, V, Ru, Sm, or In. In addition, an inorganic electron transport layer high in resistance (resistivity: 1 - 1 $\times 10^{11}\ \Omega \cdot$ cm) may be included in at least one layer of the light-emitting body. The inorganic hole injection layer contains a metal element selected from Au, Cu, Fe, Ni, Ru, Sn, Cr, Ir, Nb, Pt, W, Mo, Ta, Pd, or Co; or an oxide, an carbide, a nitride, a silicide, or a boride thereof. In addition, the inorganic hole injection layer may contain an oxide of silicon, germanium, or silicon germanium as a main component. By using a stable inorganic insulating film in a part of the light-emitting body, reliability of a light-emitting device can be enhanced.

[0084]

In addition, the counter electrode 512 can use an aluminum film or a silver thin film containing an element belonging to group 1 or 2 of the periodic table. Moreover, the passivation film 513 can use an insulating film exhibiting high blockability against moisture and oxygen, such as a silicon nitride film, an aluminum nitride film, a diamond-like carbon film, or the like.

[0085]

In fabricating a light-emitting device of the above structure, implementing the present invention makes it possible to produce a light-emitting device high in throughput by a low cost and a simple method. Furthermore, the reliability of the light-emitting device can be also improved.

[0086]

(Embodiment Mode 10)

The present embodiment mode shows an example of a multi-chamber schemed manufacturing apparatus automated in the process of from forming a light-emitting body to sealing the light-emitting element in FIG. 9. In FIG. 9, 11 is an accepted substrate stock chamber; 12, 14a, 18, and 24 are transport chambers (also called common chambers) for transporting a substrate to be processed into each chamber; 15, 17, and 21 are delivery chambers for delivering a substrate between the transport chambers; and 29 is an unloading chamber of a processed substrate. In addition, 13 is a pre-processing chamber, to previously clean an electrode surface or adjust a work function before forming a light-emitting body.

[0087]

In addition, 16R, 16G, and 16B are deposition chambers for light-emitting layers corresponding to red, blue, and green, respectively. 16H is a deposition chamber for a hole injection layer (HIL) or a hole transport layer (HTL). 16E is a deposition chamber for an

electron injection layer (EIL) or an electron transport layer (ETL). By providing a solution-applying device as a characteristic of the present invention in any one or a plurality of these deposition chambers, the present invention can be carried out. Incidentally, in a case where there is a need to use a spin coating method for depositing a hole injection layer, a hole transport layer, an electron injection layer, or an electron transport layer, a deposition chamber for spin coating may be provided separately.

[0088]

In addition, 19 is a deposition chamber for an oxide conductor film, 20 is a deposition chamber for depositing a metal film to be a cathode, and 23 is a deposition chamber for depositing an insulating film used as a passivation film. The deposition chamber 20 can be made as a deposition chamber using an evaporation method. However, in the case of evaporation, because there is a concern that deterioration occurs in the TFT and luminescent material due to radiation with X-rays, electron beams, or the like, the deposition chamber is preferably formed by a sputtering method.

[0089]

In addition, 27 is a sealing substrate load chamber for stocking a sealing substrate for sealing, 25 is a dispenser chamber for forming a seal material, and 26 is a seal chamber for bonding a processed substrate and a sealing substrate together to thereby seal the light-emitting element. Owing to the provision of the sealing chamber and the like, the manufacturing apparatus shown in the present embodiment can seal the light-emitting element without exposure of the light-emitting element to the atmosphere even once, and thus it provides an effective structure in realizing a highly reliable light-emitting device.

[0090]

In the manufacturing apparatus of FIG. 8, the chambers are partitioned by gate valves respectively, and this enables hermetic shield from other chambers. Furthermore, the chambers are coupled to vacuum exhaust pumps respectively and thus allowed to maintain a vacuum and to introduce an inert gas and then provide a reduced pressure atmosphere. The vacuum exhaust pump can use a magnetic-levitation-type turbo molecule pump, a cryo-pump or a dry pump. In addition, the inert gas introduced is preferably previously passed through a refiner or the like into high purity.

[0091]

Incidentally, the structure of the manufacturing apparatus shown in Fig. 9 is a mere one example, and the present invention is not limited at all. The present embodiment mode shows the capability of combining the solution-applying device for carrying out the manufacturing

method of a light-emitting device of the present invention with a multi-chamber-schemed manufacturing apparatus, and can be carried out in a case of fabricating a light-emitting device through a combination with any structure of Embodiment Modes 1 - 8.

[0092]

(Embodiment Mode 11)

In the present embodiment mode, FIG. 10 shows an example in which the solution-applying device used in carrying out the present invention is combined with an in-line schemed manufacturing apparatus for the process from forming a light-emitting body up to forming a cathode. Incidentally, FIG. 10(A) is a top view and FIG. 10(B) is a side view.

[0093]

In FIGS. 10(A) and (B), 41 is a load chamber for transporting a substrate, 42 is an unload chamber for delivering a substrate, 43 is a deposition chamber for depositing a hole injection layer, 44 is a deposition chamber for depositing a hole transport layer, 45 is a deposition chamber for depositing a light-emitting layer, 46 is a deposition chamber for depositing an electron injection layer, and 47 is a deposition chamber for depositing a metal film to be a cathode. An arrow 50 in the figure indicates a transport direction of a substrate 40, and the substrate already processed is represented by the dotted line. At this time, the substrate 40 in a state where a surface to be processed is placed with the bottom up, is set up in a range of 0° to 30° relative to the horizontal plane and transported to each deposition chamber.

[0094]

The deposition chambers 43 - 46 are solution-applying devices for carrying out the present invention, within which heads 43a, 44a, 45a, and 46a are provided underneath the substrate. Each of those heads has a structure explained in Embodiment Mode 1 or Embodiment Mode 2, to apply a solution containing an organic compound or inorganic compound and form a thin film under a reduced pressure. Of course, a mechanism for heating the substrate 40 at room temperature (typically 20 °C) to 30 °C, further preferably 50 to 200 °C may be provided. An arrow 51 shows a moving direction of the head 45a, and it moves in parallel with the substrate surface from one end to the other end of the substrate 40, and thus solution application and thin film formation is carried out. Incidentally, the distance (L) between the substrate 40 and a tip (ejection port) of the head 45a is 2 - 20 mm. A solution containing an organic compound or an inorganic compound is ejected from the head positioned beneath the substrate, against the direction of gravity. The solute is applied onto the substrate.

[0095]

In addition, in FIG. 10(B), the side view of the deposition chamber (light-emitting layer)

45 corresponds to a manner of the head moving along the substrate surface as viewed from the side surface. At this time, in the deposition chambers 43 - 46, there is a flow of nitrogen, inert gas and other fluoride gas in a direction of an arrow 52. Between the substrate 40 and the heads 43a - 46a, a laminar flow is formed by an inert gas. At this time, the flowing inert gas can be heated in place of or together with heating the substrate. Of course, it is possible to use reduced pressure without introducing an inert gas.

[0096]

The deposition chamber 47 is a chamber for depositing a metal film to be a cathode by the sputtering method. Deposition is carried out while the substrate 40 is passing aside a rectangular target 47a. For example, it is possible to form a metal film containing an element belonging to group 1 or 2 of the periodic table, e.g. an alloy film of aluminum and lithium. Incidentally, the shape of the target 47a is not limited to this.

[0097]

Note that a feature of the present invention includes a point that there is no need for a baking process and the like because thin film is made simultaneously with solution application. However, a baking process of heating or the like under a reduced pressure may be carried out between the deposition chambers 43 - 47. This is because, if a solvent component is removed from a thin film of a light-emitting layer or the like, reliability can be considered to improve correspondingly.

[0098]

(Embodiment Mode 12)

In the present embodiment mode, FIG. 11 shows an example in which the solution-applying device used in carrying out the present invention is combined with an in-line schemed manufacturing apparatus for the process from forming a light-emitting body up to sealing the light-emitting element. Incidentally, FIG. 11(A) is a top view of the manufacturing apparatus and FIG. 11(B) is a side view of the manufacturing apparatus.

[0099]

In FIGS. 11(A) and (B), 61 is a load chamber for transporting a substrate, 62 is an unload chamber for delivering a substrate, 63 is a deposition chamber for depositing a hole injection layer, 64 is a deposition chamber for depositing a light-emitting layer, 65 is a deposition chamber for depositing an electron injection layer, 66 is a deposition chamber for depositing a metal film to be a cathode, and 67 is a deposition chamber for depositing a protection film having a passivation effect. An arrow 70 in the figure is a transport direction of a substrate 60, and the substrate already processed is represented by the dotted line. At this time, the substrate

60 is placed horizontally and transported with the lower side of the substrate rendered as a surface to be processed.

[0100]

The deposition chambers 63 - 65 are solution-applying devices for carrying out the present invention, within which heads 63a, 64a, and 65a are provided. Each of these heads has a structure explained in Embodiment Mode 1 or Embodiment Mode 2, to apply a solution containing an organic compound or an inorganic compound and form a thin film under a reduced pressure. Of course, a mechanism for heating the substrate 60 at room temperature (typically 20 °C) to 30 °C, further preferably 50 to 200 °C may be provided.

[0101]

In addition, in FIG. 11(B), the side view of the deposition chamber (light-emitting layer) 64 corresponds to a manner of the head moving along the substrate surface as viewed from the above. An arrow 71 denotes a moving direction of the head 64a, and it moves in parallel with the substrate surface from one end to the other end of the substrate 60, and thus solution application and thin film formation is carried out. Incidentally, the distance (L) between the substrate 60 and a tip (ejection port) of the head 64a is 2 - 20 mm.

[0102]

Furthermore, at this time, in the deposition chambers 63 - 65, there is a flow of nitrogen, inert gas and other fluoride gas in a direction of an arrow 72. Between the substrate 60 and the heads 63a - 65a, a laminar flow is formed by inert gas. At this time, the flowing inert gas can be heated in place of or together with heating the substrate. Of course, it is possible to use a reduced pressure without introducing an inert gas.

[0103]

In addition, the deposition chamber 66 is a chamber for depositing a metal film to be a cathode by the sputtering method. Deposition is carried out while the substrate 60 is passing aside a rectangular target 66a. For example, it is possible to form a metal film containing an element belonging to group 1 or 2 of the periodic table, e.g. an alloy film of aluminum and lithium. Incidentally, the shape of the target 66a is not limited to this.

[0104]

In addition, the deposition chamber 67 is a chamber for depositing an insulating film having a passivation effect by the sputtering method (preferably radio-frequency sputtering method). Deposition is carried out while the substrate 60 is passing aside a rectangular target 67a in the same manner as in Embodiment Mode 7. For example, it is possible to form a highly dense silicon compound film, such as a silicon nitride film, a silicon nitride oxide film.

Incidentally, the shape of the target 67a is not limited to this.

[0105]

Note that a feature of the present invention includes a point that there is no need for a baking process and the like because thin film is made simultaneously with solution application. However, a baking process of heating or the like under a reduced pressure may be carried out between the deposition chambers 63 - 66. This is because, if a solvent component is removed from a thin film of a light-emitting layer or the like, reliability can be considered to improve correspondingly.

[0106]

(Embodiment Mode 13)

The defect of ink-jet scheme lies in that, when ejection of a solution is ceased, the solvent volatilizes and dries at the ejection port to thereby cause clogging in the head of the ejection port. One of the conventional methods for preventing this is to prevent drying by continuously ejecting the solution incessantly. Accordingly, because the solution is wastefully ejected and discharged, the efficiency in the use of a light-emitting body composition lowers. The present embodiment mode explains means for preventing the head of the ejection port from drying with reference to FIG. 12.

[0107]

FIGS. 12(A) and (B) are views of a manufacturing process of a light-emitting body in the present embodiment mode as viewed from the below and the side of the substrate, respectively. A head 801 of a solution-applying device positioned underneath a substrate 800 is scanned in the direction of the arrows. From the head 801, a solution containing a light-emitting body composition is ejected in the form shown in Embodiment Modes 1 - 3, to form a light-emitting body 82 without the need to especially provide a baking process. At this time, the present embodiment mode is characterized in that a container part 803 for containing the head 801 after scanning is provided alongside the substrate 800. The interior thereof is filled with a gas of a volatilized solvent. The gas of the volatilized solvent (gas containing a solvent component), after introduced from an introduction port 804, fills the container part 803 through a plurality of openings 805 positioned underneath the container part 803.

[0108]

Incidentally, the "gas of volatilized solvent" is a solvent capable of dissolving a light-emitting body to be formed, which is preferably the same one as the solvent of a solution containing a light-emitting body composition ejected at the head 801. Of course, there is no necessity to limit it to the same one. The solvent may be changed as appropriate depending

upon the kind of a light-emitting body to form.

[0109]

FIG. 12(C), (D) shows a state of the head 801 at a time when the forming process of a light-emitting body is ended. As shown in FIG. 12(C), (D), the head 801 is accommodated so as to be completely hidden within the container part 803, and thus exposed to a solvent gas atmosphere. At this time, it is effective to provide a lid on the container part 803 so that, after the head 801 is accommodated, the lid is shut to suppress the solvent component from diffusing to the outside. Of course, because the head is fixed and scanned by a not shown support material or the like, the lid is naturally closed to avoid it.

[0110]

As described above, the present embodiment mode is characterized in that, after ending the forming process of a light-emitting body, the head is exposed to an atmosphere filled with a solvent capable of dissolving a light-emitting body to be formed. Due to this, in the ejection port of the head 801, because the light-emitting body composition is dissolved by the solvent, clogging does not occur due to drying or the like. In other words, because of an environment free from drying even if ejection of the light-emitting body composition ceases, there is no need to usually eject a solution continuously and thereby prevent from drying like a conventional ink-jet scheme. Therefore, the ratio of discharge by wasteful ejection is reduced, and thus the efficiency in the use of a light-emitting body composition can be improved.

[0111]

Incidentally, the technical idea that, after application, the head is exposed to the atmosphere filled with the solvent component and prevented from drying can be naturally applied to a case where the surface to be processed is taken above the substrate or a case where the substrate is placed vertically.

[0112]

In addition, the present embodiment mode can be combined with a manufacturing apparatus having any structure of Embodiment Modes 4, 5, 10 - 12, and used in a fabrication method of a light-emitting device having any structure of Embodiment Modes 7 - 9.

[0113]

(Embodiment Mode 14)

The present embodiment mode explains a head structure of a solution-applying device used in a fabrication method of a light-emitting device according to the present invention with reference to FIG. 13. Incidentally, the present embodiment mode takes a form to apply a substrate horizontally placed with the surface to be processed facing downward (corresponding

to Embodiment Modes 10, 11). However, it is needless to say that practicing is possible in a case where the surface to be processed of the substrate faces upward or a case where the substrate is positioned vertically.

[0114]

In FIG. 13(A), a substrate 901 is supported with a susceptor 902 of a magnetic body and placed horizontally with the surface to be processed positioned lower. A head 903 of a solution-applying device is provided close to a surface of the substrate 901. At this time, the magnifying part at a tip of a nozzle (ejection port) 904 is shown by a dotted-lined part 905. The nozzle interior has a hollow structure, having a core 906 fixed in an inner position than that and a cap (hereinafter referred to as a magnetic body cap) 908 made by a magnetic body coupled to the core 906 through an elastic body (spring in the present embodiment mode) 907. A solution 909 containing a light-emitting body composition fills the outside of the hollow structure.

[0115]

A material for the magnetic body cap 908 is selected such that repulsive force acts against the susceptor 902 of a magnetic body. In the case of FIG. 13(A), the distance (X1) between the substrate 901 and the magnetic body cap 908 is a distance with which repulsive force does not effectively acts between the susceptor 902 and the magnetic body cap 908, which is determined by a material of a magnetic body, a substrate thickness, etc. In the case where repulsive force does not effectively acts between the susceptor 902 and the magnetic body cap 908, the magnetic body cap 908 is pushed by the elastic body 907 and lodges the tip of the nozzle 904, to prevent the solution 909 containing a light-emitting body composition from ejecting.

[0116]

In addition, after commencing solution application, the distance between the substrate 901 and the magnetic body cap 908 is reduced to X2, as shown in FIG. 13(B). This distance X2 is a distance with which repulsive force fully acts between the susceptor 902 and the magnetic body cap 908. By this repulsive force, the magnetic body cap 908 compresses the elastic body 907 and is pushed into the inside of the hollow structure. Due to this, a space is secured at the tip of the nozzle 904, to eject the solution 909 containing a light-emitting body composition. In this manner, the solution 909 containing a light-emitting body composition is applied to a surface of the substrate 901. The solvent is volatilized under a reduced pressure or the solvent is volatilized by the heating of the substrate 901, and thereby a light-emitting body 910 is formed.

[0117]

As the above, by using magnetic bodies having a relationship as causing to act a repulsive force on each other, it is possible to provide a structure for applying an internal solution when they are brought close to a certain distance; thus, a uniform distance can be ensured between the substrate and the head (exactly, nozzle). In addition, by controlling the distance between the substrate and the head, on-off of ejection can be controlled. This technique is effective particularly in the case of applying a solution onto a substrate having projections and depressions.

[0118]

Incidentally, the present embodiment mode can be combined with a manufacturing apparatus having any structure of Embodiment Modes 4, 5, 10 - 13. Moreover, it can be used in a manufacturing method of a light-emitting device having any structure of Embodiment Modes 7 - 9.

[0119]

(Embodiment Mode 15)

The present embodiment mode explains an example using a multi-chamber schemed manufacturing apparatus, in a light-emitting device manufacturing apparatus for substrate transportation and deposition as shown in Embodiment Modes 13 and 14 with reference to FIG. 14. Incidentally, the chambers are mutually coupled by gate valves, thereby a hermetic state is kept.

[0120]

In FIG. 14, a carrier 702 for transporting a substrate is set up in a stock chamber 701. The stock chamber 701 is coupled to a transport chamber 703 through the gate valve. The substrate furnished on the carrier 702 is transported by a transport arm 704 and placed on a substrate mounting table 705. At this time, the substrate is first put on a pusher pin 706 and thereafter the pusher pin 706 is lowered to place the substrate on the substrate mounting table 705. The substrate mounting table 705 after fixing the substrate moves to the inside of a load/unload chamber 707, to deliver the substrate to a susceptor 700. Incidentally, in FIG. 14, the portion of the susceptor 700 represented by the dotted line means the position of the susceptor in processing a substrate and means that the substrate and the susceptor moves in unison as the process proceeds so that it currently does not exist there.

[0121]

The substrate delivered in the load/unload chamber 707 moves in unison with the susceptor 700 along a rail, and thus is transported to a common chamber 708 coupled by the gate valve. A turntable 709 is provided within the transport chamber 708. When the susceptor

700 is put upon the turntable 709, the turntable 709 rotates to select a chamber for performing the next process, which is coupled to the common chamber through the gate valve.

[0122]

The manufacturing apparatus in the present embodiment mode is provided, as processing chambers, with a deposition chamber (HTL deposition chamber) 710 for depositing a hole transport layer (HTL), a deposition chamber (light-emitting layer deposition chamber) 711 for depositing a light-emitting layer, a deposition chamber (ETL deposition chamber) 712 for depositing an electron transport layer (ETL), and a deposition chamber (sputter deposition chamber) 713 for depositing a conductor film by a sputtering method. The deposition chambers 710 - 712 for forming a light-emitting body are each provided with a solution-applying device explained in Embodiment Modes 1 - 3, which are chambers for depositing a light-emitting body composition by solution application such as inkjet. Incidentally, in each chamber, heads 710a - 712a of a solution-applying device are provided underneath the substrate. These heads are scanned in parallel with the substrate while ejecting a solution in a direction toward the substrate, thereby forming a thin film.

[0123]

In addition, the deposition chamber 713 for depositing a cathode by a sputtering method is provided with electrodes 714, 715, and a target 716 for sputtering. These are all in a cylindrical or oblong elliptic form. The substrate attached to the susceptor 700 is transported in the direction of the arrow, and a film is formed while the substrate passes aside the target 716. At this time, the sputtering method may use either of a DC (direct current) sputtering method and a RF (alternating current) sputtering method.

[0124]

The substrate (susceptor) in which the process at each chamber is finished is returned to the load/unload chamber 707, and accommodated in the carrier 702 via the substrate mounting table 705 and the like. As described above, the process up to and including the formation of a cathode of a light-emitting element is completed. Incidentally, although the present embodiment mode explained the manufacturing apparatus for carrying out the process up to and including the formation of a cathode, the number of chambers can be increased to complete passivation film (protection film) formation and seal process by a seal can or the like. Moreover, the light-emitting body structure is not limited to this embodiment mode but can be applied to a composite form as shown in Embodiment Mode 6. In such a case, the number of chambers, the processing content in the deposition chamber and others may be changed.

[0125]

Incidentally, the present embodiment mode may have the structure of Embodiment Modes 4, 5 and can be used in fabricating a light-emitting device described in Embodiment Modes 8, 9. Furthermore, the deposition chamber having the structure of Embodiment Modes 13, 14 may be used.

[0126]

(Embodiment Mode 16)

This Embodiment Mode explains the overall structure of a light-emitting device fabricated by carrying out the present invention with reference to FIG. 15. FIG. 15 is a top view of a light-emitting device formed by sealing, with a seal material, a device substrate on which a thin film transistor is formed. FIG. 15(B) is a cross-sectional view on B-B' in FIG. 15(A), and FIG. 15(C) is a cross-sectional view on A-A′ in FIG. 15(A).

[0127]

On the substrate 81, a pixel part (display part) 82, a data line drive circuit 83 provided so as to surround the pixel part 82, gate line drive circuits 84a, 84b, and a protection circuit 85 are arranged. A seal material 86 is provided so as to surround them. The pixel part 82 has a light-emitting element fabricated by carrying out the present invention. The seal material 86 can use a UV curable resin, an epoxy resin or other resins but preferably use a material possibly low in wettability. Incidentally, the seal material 86 may be provided to overlap with a part of the data line drive circuit 83, gate line drive circuits 84a, 84b and a protection circuit 85, or provided so as not to overlap with those circuits.

[0128]

A sealing member 87 is bonded with the use of the seal material 86, to form a hermetic space 88 by the substrate 81, the seal material 86, and the sealing member 87. The sealing member 87 can use a glass material, a metal material (typically, stainless steel), a ceramic material or plastics (including a plastic film). In addition, sealing can be performed using only an insulating film as shown in Embodiment Mode 8.

[0129]

Incidentally, in the case where the sealing member 87 uses a material different from the substrate 81, the adhesion of the seal material 86 would be spoiled due to difference in thermal expansion coefficient. Accordingly, the sealing member 87 preferably uses the same material as the substrate 81 for forming transistors thereon. In other words, it is desirable to use a substrate having the same thermal expansion coefficient as the substrate 81. In the present embodiment, glass is used as the material of the substrate 81 and sealing member 87. Furthermore, the sealing member 87 is regulated in thermal expansion coefficient through the

same thermal history as the thermal history of the substrate 81 in a transistor fabrication process.

[0130]

An absorbent (barium oxide, calcium oxide, or the like) 89 is previously provided in a recess of the sealing member 87, to absorb moisture, oxygen, and the like and to keep a clean atmosphere within the hermetic space 28, thus functions to suppress deterioration of the EL layer. The recess is covered with a cover 90 in a finely meshed form. The cover 90 passes air and moisture but does not pass the absorbent 89. Incidentally, the hermetic space 88 may be filled with an inert gas, such as nitrogen or argon. Filling can be performed using a resin or a liquid if inactive.

[0131]

In addition, on the substrate 81, a terminal 91 is provided for conveying a signal to the data line drive circuit 83 and gate line drive circuits 84a, 84b. To the terminal 91, a data signal such as a video signal is conveyed through an FPC (flexible printed circuit) 92. The terminal 91 has a section as in FIG. 14(B), in which electrical connection is provided with a conductor 96 in which a resin 97 is dispersed, between a wiring in a structure laying an oxide conductor film 34 on a wiring 93 formed simultaneously with the gate line or data line and a wiring 95 provided close to the FPC 92. Incidentally, the conductor 96 may use a spherical polymer compound plated with gold or silver.

[0132]

In the present embodiment mode, the protection circuit 85 is provided between the terminal 91 and the data line drive circuit 83. When static electricity such as a surge pulse signal enters between the both, the protection circuit functions to release the pulse signal to the outside. At that time, a high voltage signal which first instantaneously enters is blunted by a capacitor. The other high voltage can be released to the outside by a circuit structured with the use of thin film transistors or thin film diodes. Of course, the protection circuit may be provided in other place, e.g. between the pixel part 82 and the data line drive circuit 83 or between the pixel part 82 and the gate line drive circuits 84a, 84b.

[0133]

(Embodiment Mode 17)

Although both the thin film transistors which are shown in Embodiment Modes 8 and 9 have a top-gate structure (specifically, planar structure), a bottom-gate structure (specifically, an inverted staggered structure) can be used in each embodiment.

[0134]

Naturally, the present invention can be applied to a transistor in a MOS structure formed using a silicon-well without limitation to the thin film transistor. Furthermore, besides the thin film transistor, the present invention may be applied to a case of using a diode element (also called a two-terminal element) typified by a MIM (Metal-Insulator-Metal) element or the like.

[0135]

In any way, native effect of the present invention is not impaired depending on the structure of a switching element such as a transistor structure even when it is implemented in fabricating an active-matrix type light-emitting device.

[0136]

(Embodiment Mode 18)

By incorporating a light-emitting device obtained by carrying out the present invention in a display portion, an electronic appliance can be fabricated. The electronic appliance includes a video camera, a digital camera, a goggle-type display (a head mounted display), a navigation system, an audio reproducing apparatus (a car audio, an audio component, etc.), a notebook personal computer, a game apparatus, a personal digital assistant (a mobile computer, a cellular phone, a portable game machine, an electronic book, etc.), an image reproducing apparatus having a recording medium (specifically, an apparatus for reproducing a recording medium such as a digital versatile disc (DVD) and having a display for displaying an image thereof), and so on. The concrete examples of those electronic appliances are shown in FIG. 16.

[0137]

FIG. 16(A) is a television set including a housing 2001, a support base 2002, a display portion 2003, a speaker 2004, a video input terminal 2005, and the like. The present invention can be applied to the display portion 2003. Incidentally, included are all the television for displaying information set for personal computers, for receiving TV broadcast, for advertisement display, etc.

[0138]

FIG. 16(B) is a digital camera including a main body 2101, a display portion 2102, an image receiver 2103, operation keys 2104, an external connection port 2105, a shutter 2106, etc. The present invention can be applied to the display portion 2102.

[0139]

FIG. 16(C) is a notebook type personal computer including a main body 2201, a housing 2202, a display portion 2203, a keyboard 2204, an external connection port 2205, a pointing mouse 2206, etc. The present invention can be applied to the display portion 2203.

[0140]

FIG. 16(D) is a mobile computer including a main body 2301, a display portion 2302, a switch 2303, operation keys 2304, an infrared-ray port 2305, etc. The present invention can be applied to the display portion 2302.

[0141]

FIG. 16(E) is a portable-type image reproducing apparatus (specifically, a DVD reproducing apparatus) having a recording medium, including a main body 2401, a housing 2402, a display portion A 2403, a display portion B 2404, a recording medium (DVD, etc.) reader portion 2405, an operation key 2406, a speaker 2407, etc. The display portion A 2403 displays mainly image information, and the display portion B 2404 displays mainly character information. The present invention can be applied to the display portions A 2403, B 2404. Incidentally, the image reproducing apparatus having a recording medium include a household game apparatus.

[0142]

FIG. 16(F) is a goggle-type display (a head mounted display) including a main body 2501, a display portion 2502 and an arm portion 2503. The present invention can be applied to the display portion 2502.

[0143]

FIG. 16(G) is a video camera including a main body 2601, a display portion 2602, a housing 2603, an external connection port 2604, a remote control receiver 2605, a receiver 2606, a battery 2607, an audio input 2608, and operation keys 2609. The present invention can be applied to the display portion 2602.

[0144]

FIG. 16(H) is a cellular phone including a main body 2701, a housing 2702, a display portion 2703, an audio input 2704, an audio output 2705, an operation key 2706, an external connection port 2707 and an antenna 2708. The present invention can be applied to the display portion 2703. Incidentally, the display portion 2703 can suppress consumption current for the cellular phone by displaying white characters on a black background.

[0145]

As described above, the display device obtained by carrying out the present invention may be used as a display portion of every electronic appliance. Incidentally, the electronic appliance in the present embodiment mode may use a light-emitting device fabricated by using any structure of Embodiment Modes 1 - 3 and 6 - 8.

[0146]

[Effect of the Invention]

The present invention makes it possible to form a thin film almost simultaneously with applying a solution containing a light-emitting body composition of an organic compound, an inorganic compound, or the like, and greatly improve the throughput in a manufacturing process of a light-emitting device.

[0147]

In addition, the solvent component in a formed thin film can be fully removed simultaneously with the film formation. Accordingly, it is possible to avoid malfunctions such as deterioration of the light-emitting layer itself due to degasification after a light-emitting element is completed, and to improve the reliability of the light-emitting device.

[Brief Description of the Drawings]

[FIG. 1] Cross-sectional views of a solution-applying device used in carrying out the present invention.

[FIG. 2] Cross-sectional views of a solution-applying device used in carrying out the present invention.

[FIG. 3] Cross-sectional views of a solution-applying device used in carrying out the present invention.

[FIG. 4] A cross-sectional view of a vessel for reserving a solution containing a light-emitting body composition, in the solution-applying device used in carrying out the present invention.

[FIG. 5] Diagrams illustrating a manufacturing method of a light-emitting device of the present invention.

[FIG. 6] Diagrams illustrating a manufacturing method of a light-emitting device of the present invention.

[FIG. 7] A top view and a cross-sectional view which illustrate a pixel structure of a light-emitting device obtained by carrying out the present invention.

[FIG. 8] A top view and a cross-sectional view which illustrate a pixel structure of a light-emitting device obtained by carrying out the present invention.

[FIG. 9] A top view of a manufacturing apparatus to be used in carrying out the present invention.

[FIG. 10] A top view and a side view of a manufacturing apparatus to be used in carrying out the present invention.

[FIG. 11] A top view and a side view of a manufacturing apparatus to be used in carrying out the present invention.

[FIG. 12] Diagrams illustrating a fabrication method of a light-emitting device in the present invention.

[FIG. 13] Cross-sectional views of a solution-applying device to be used in carrying out the present invention.

[FIG. 14] A top view of a manufacturing apparatus to be used in carrying out the present invention.

[FIG. 15] Diagrams illustrating exterior views of a light-emitting device obtained by carrying out the present invention.

[FIG. 16] Diagrams illustrating examples of electronic appliances having a light-emitting device obtained by carrying out the present invention.

[Name of Document] Abstract

[Abstract]

[Object]

The present invention is a fabrication method of a light-emitting device characterized by ejecting a solution containing a luminescent material toward an anode or a cathode under a reduced pressure and characterized in that until the solution reaches the anode or the cathode, the solvent in the solution is volatilized, and the remaining part of the luminescent material is deposited on the anode or the cathode, thereby forming a light-emitting layer. In accordance with the present invention, a baking process for reducing thickness is not required after applying the solution. Accordingly, a fabrication method with high throughput can be provided although it is a simple and low-cost method.

[Selected Drawing] FIG. 1

FIG. 1

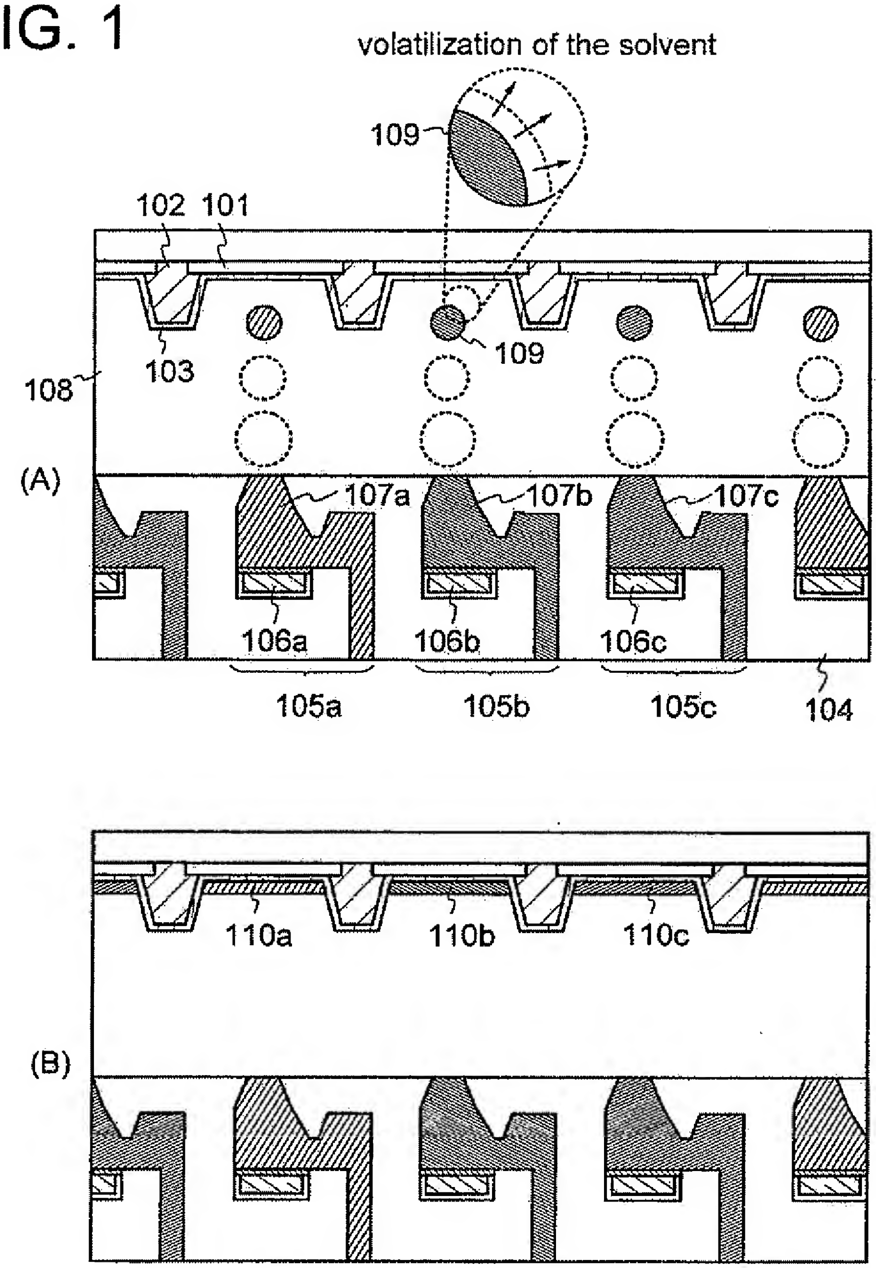
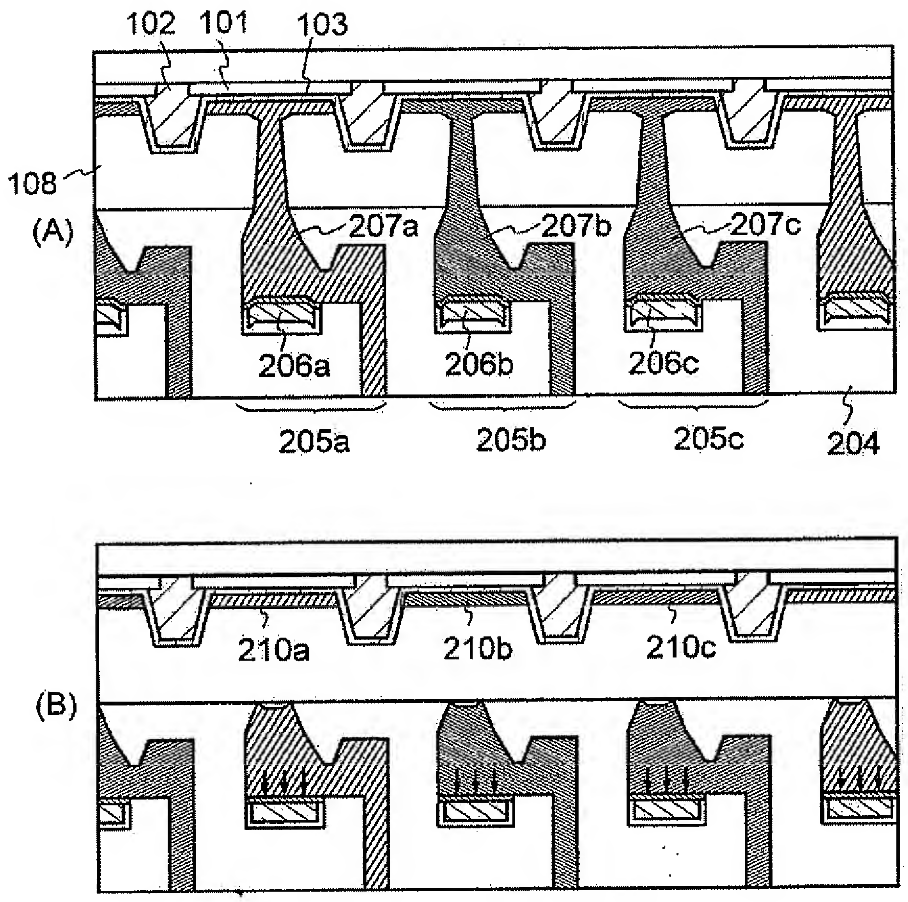
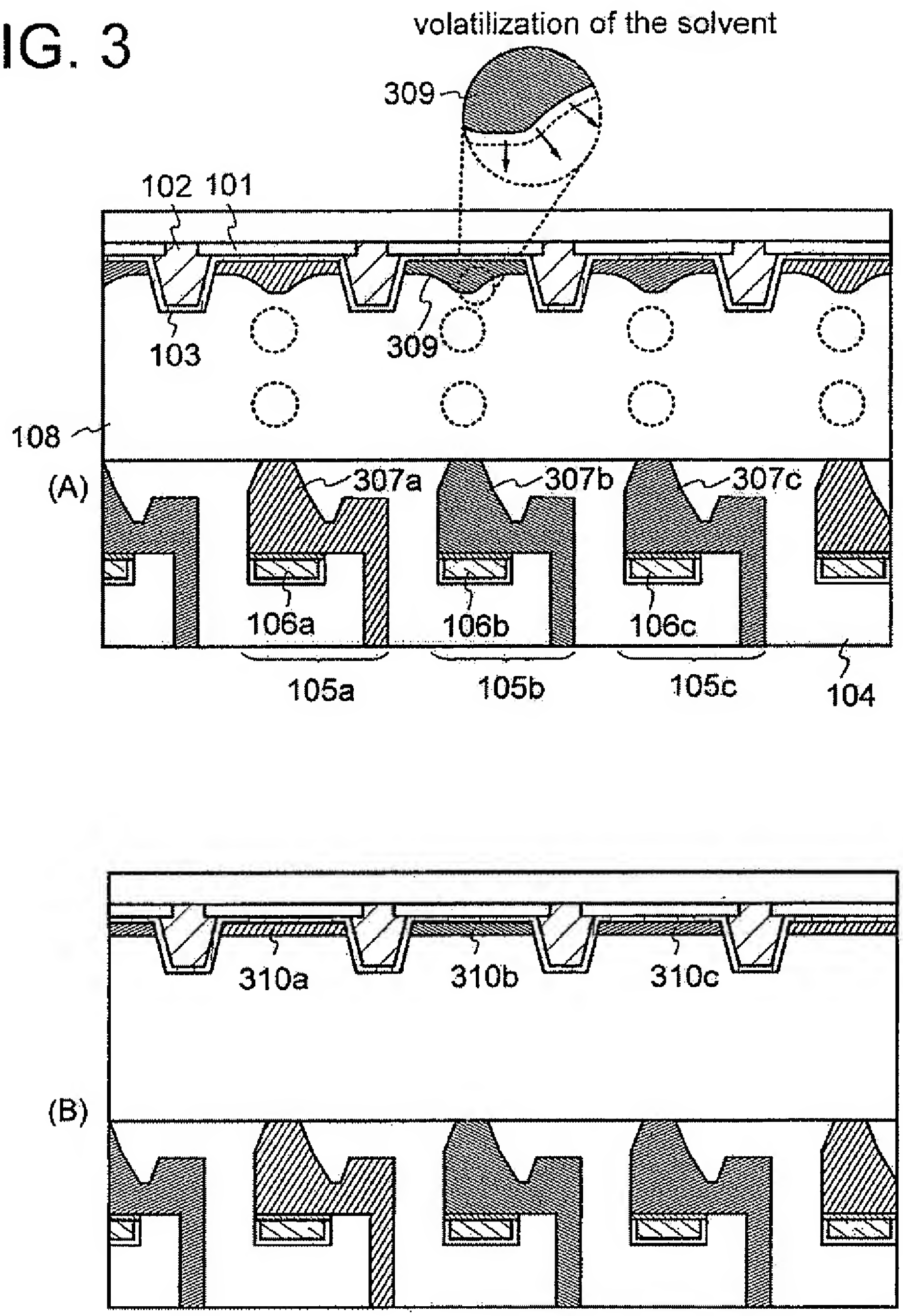

volatilization of the solvent
109
102 101
103
108
109
(A)
107a
107b
107c
106a
106b
106c
105a
105b
105c
104
110a
110b
110c
(B)

FIG. 2



102
101
103
108
(A)
207a
207b
207c
206a
206b
206c
205a
205b
205c
204
210a
210b
210c
(B)

FIG. 3



volatilization of the solvent
309
102 101
103
309
108
(A)
307a
307b
307c
106a
106b
106c
105a
105b
105c
104
310a
310b
310c
(B)

FIG. 4

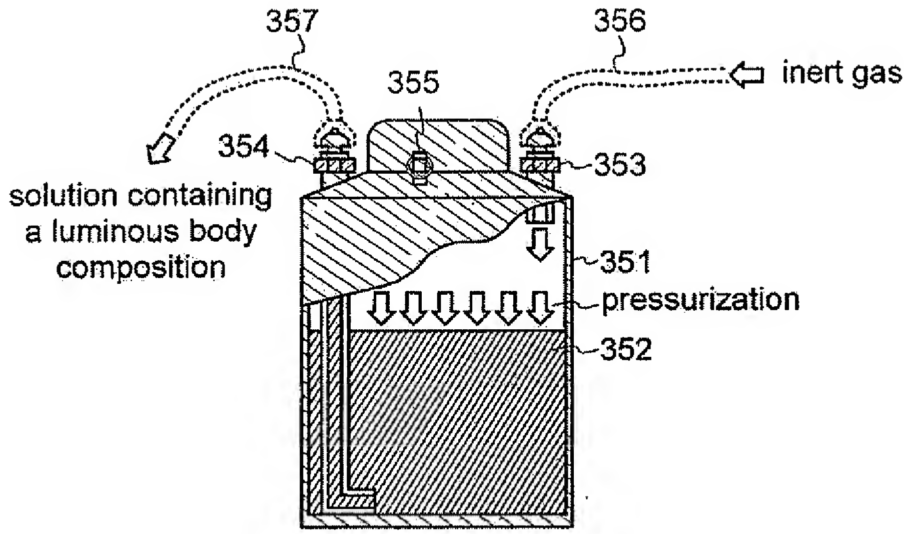

357
356
inert gas
355
354
353
solution containing a luminous body composition
351
pressurization
352

FIG. 5

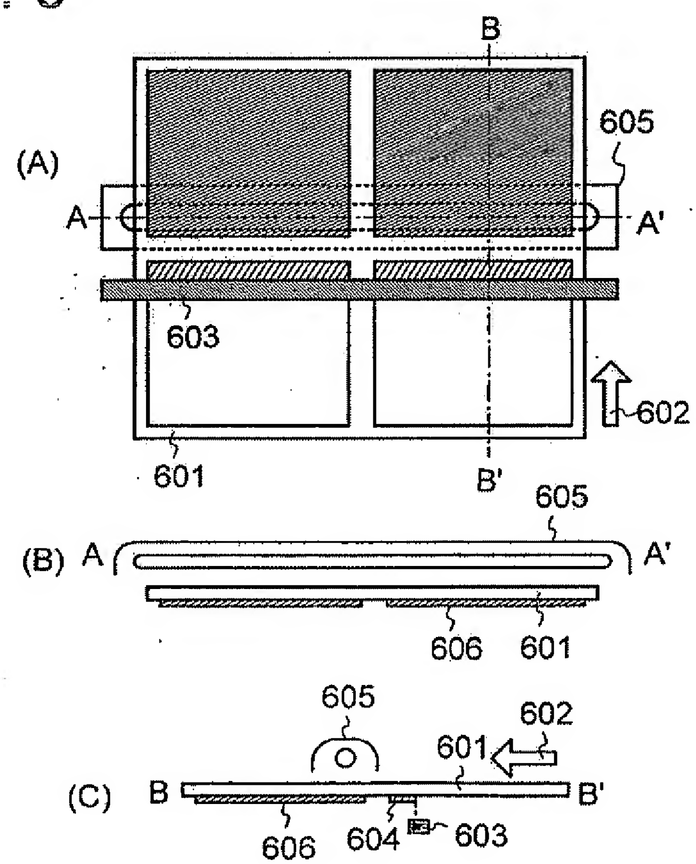

B
605
(A)
A
A'
603
602
601
B'
605
(B) A
A'
606
601
605
602
601
(C) B
B'
606
604
603

FIG. 6

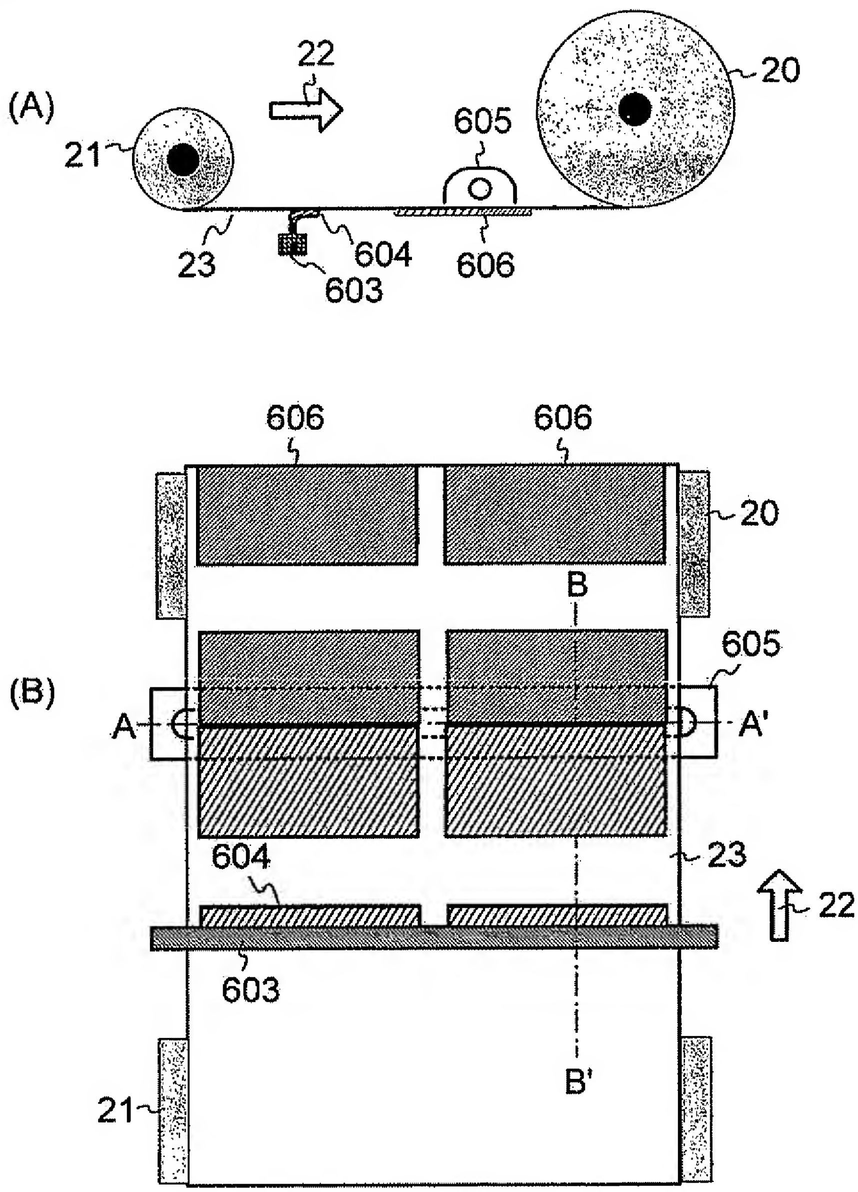
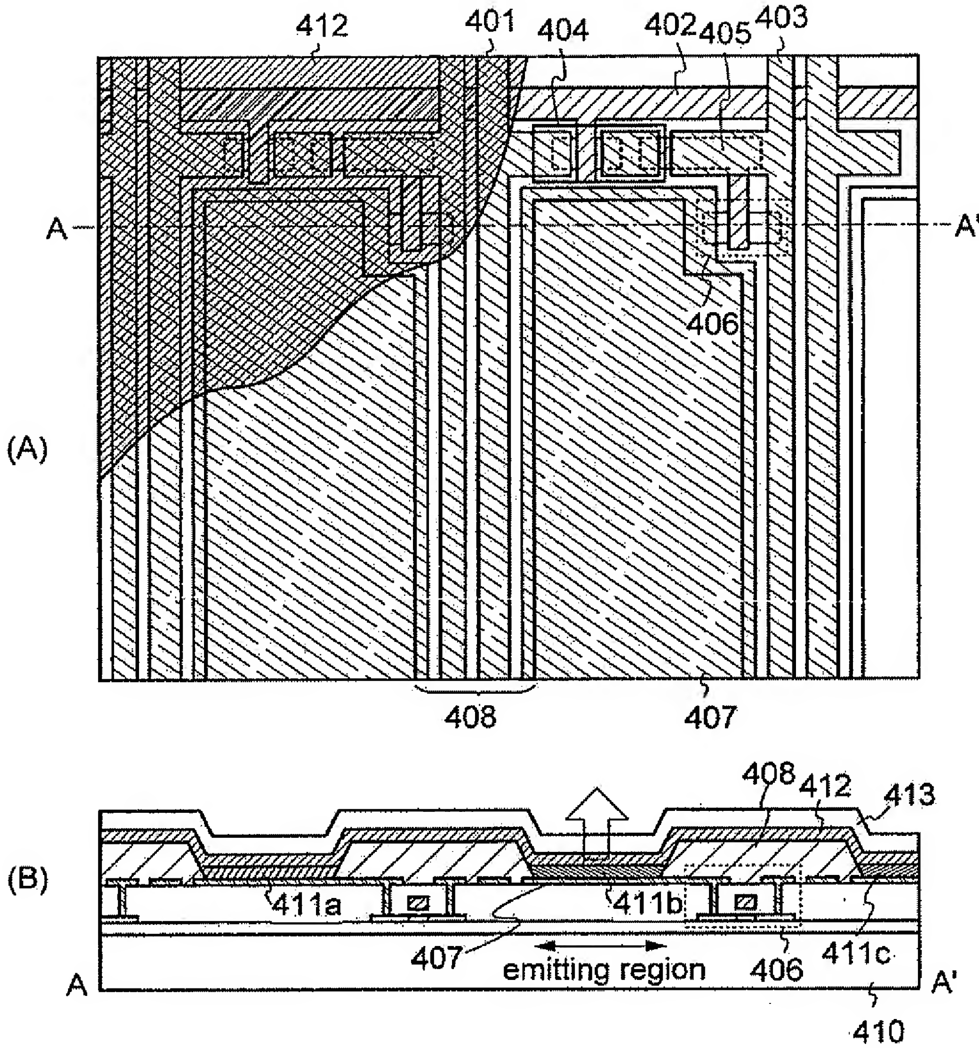


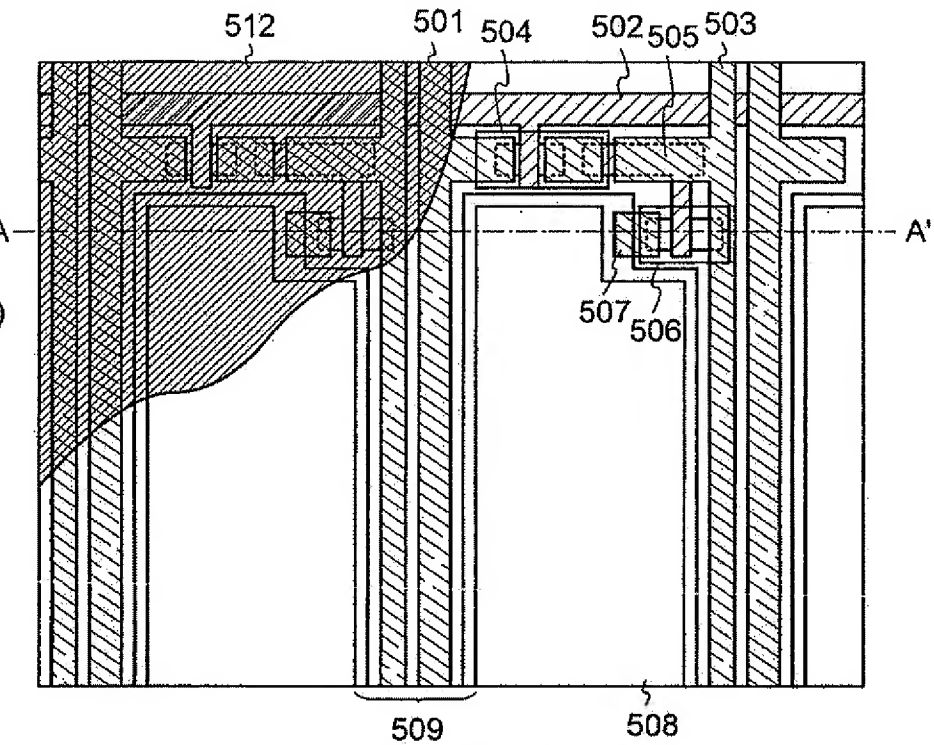
FIG. 7



412
401
404
402
405
403
A
A'
406
(A)
408
407
408
412
413
(B)
411a
411b
407
emitting region
406
411c
A
A'
410

FIG. 8

(A)


512
501
504
502
505
503
A
A'
507
506
509
508

(B)

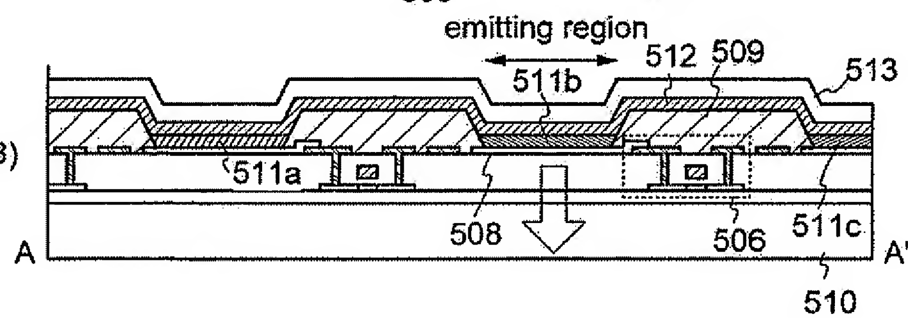
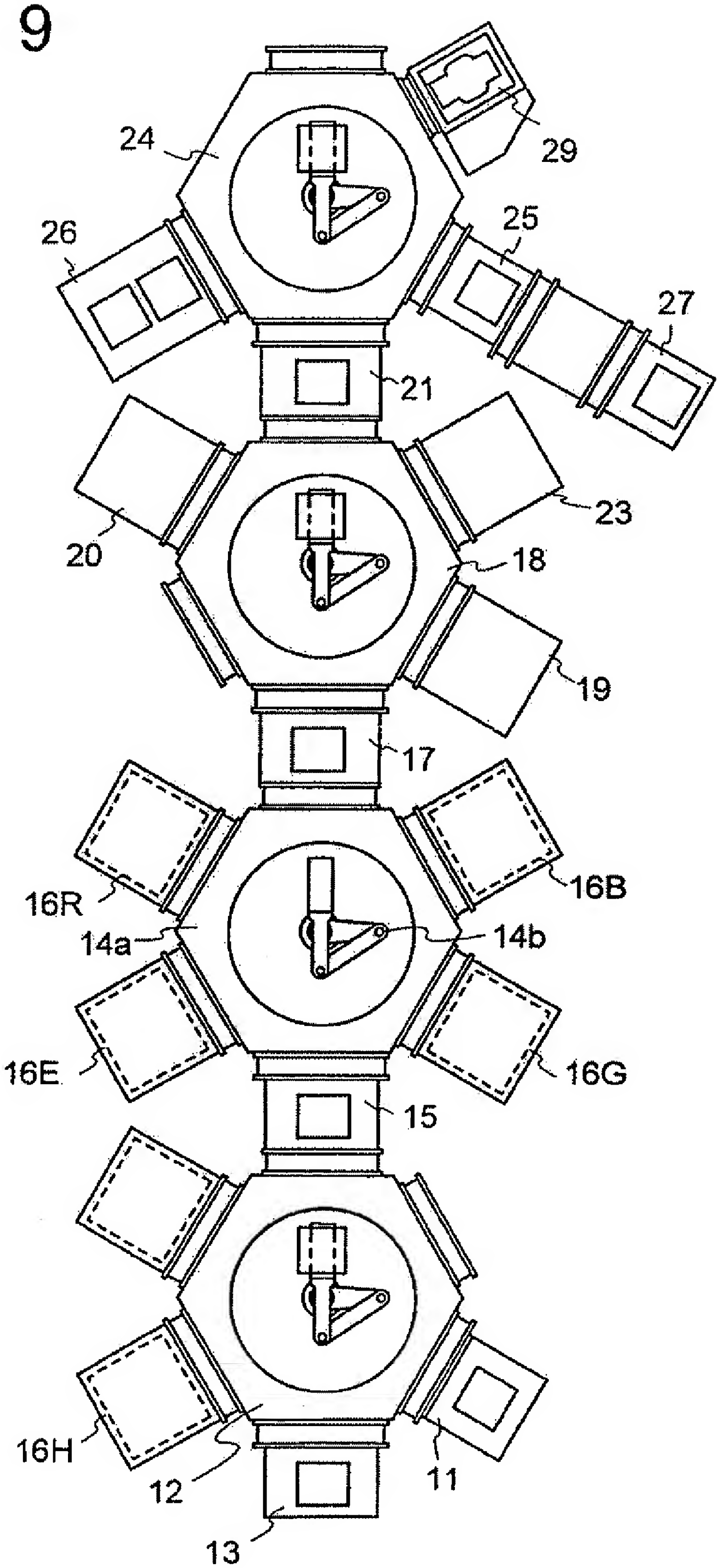
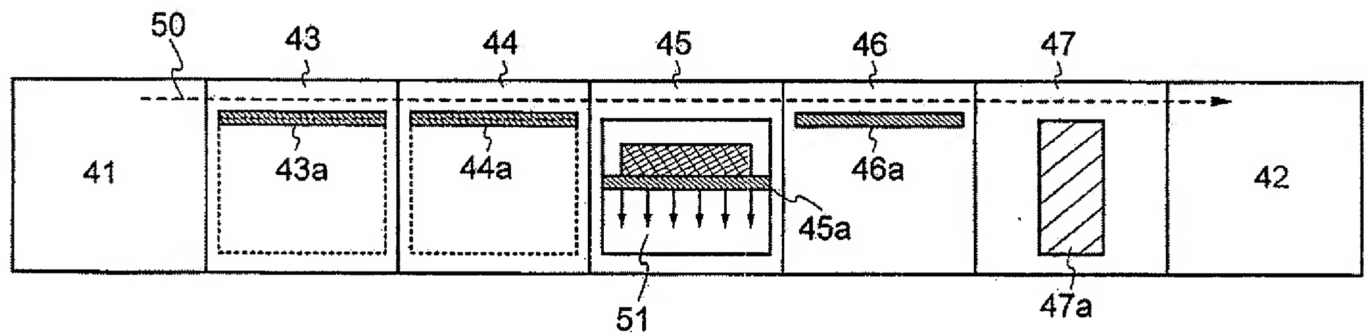

emitting region
511b
512
509
513
511a
508
506
511c
A
A'
510

FIG. 9



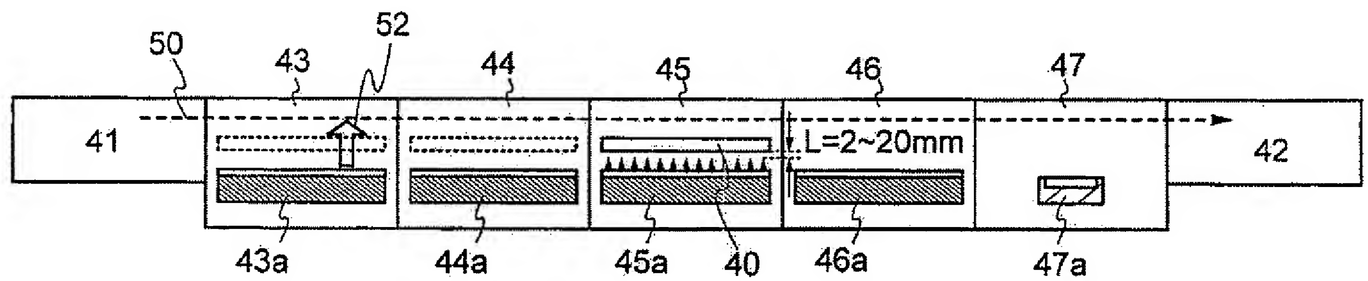
24
29
26
25
27
21
20
23
18
19
17
16R
16B
14a
14b
16E
16G
15
16H
12
11
13

FIG. 10



50
43
44
45
46
47
41
43a
44a
46a
45a
42
51
47a

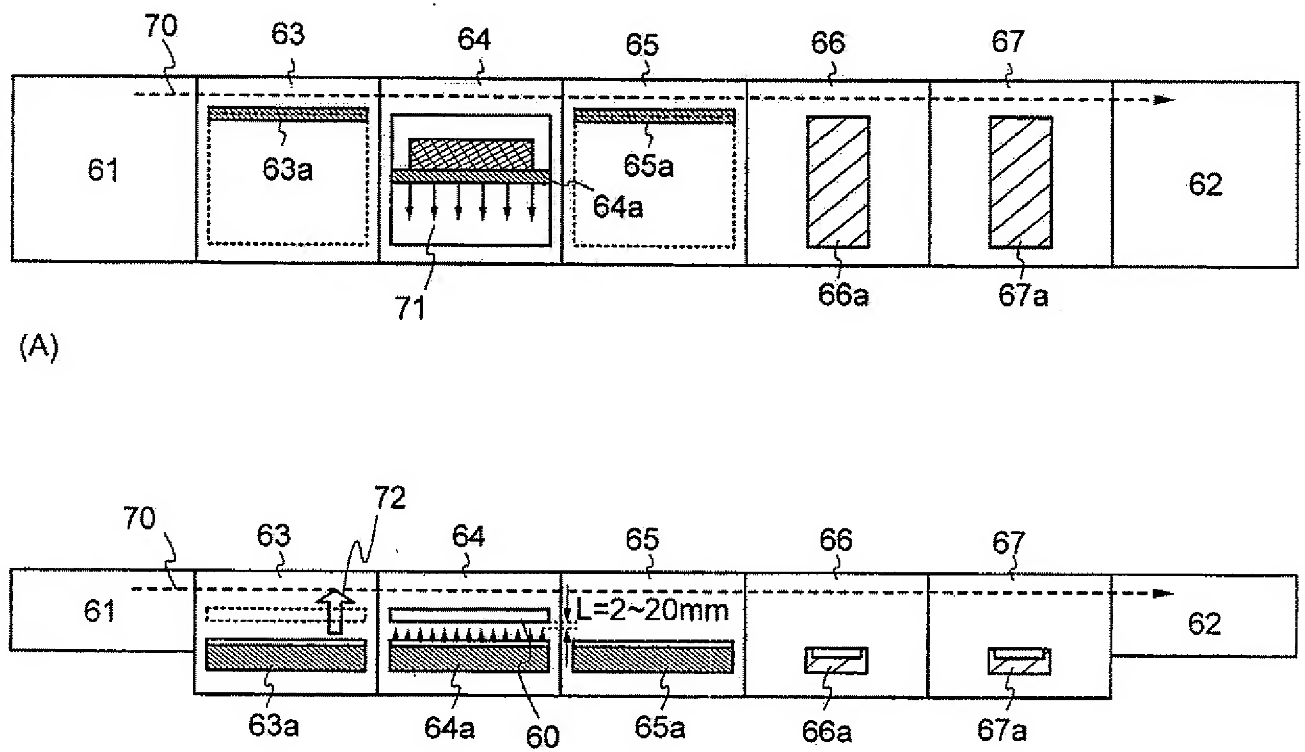
(A)



52
50
43
44
45
46
47
41
L=2~20mm
42
43a
44a
45a
40
46a
47a

(B)

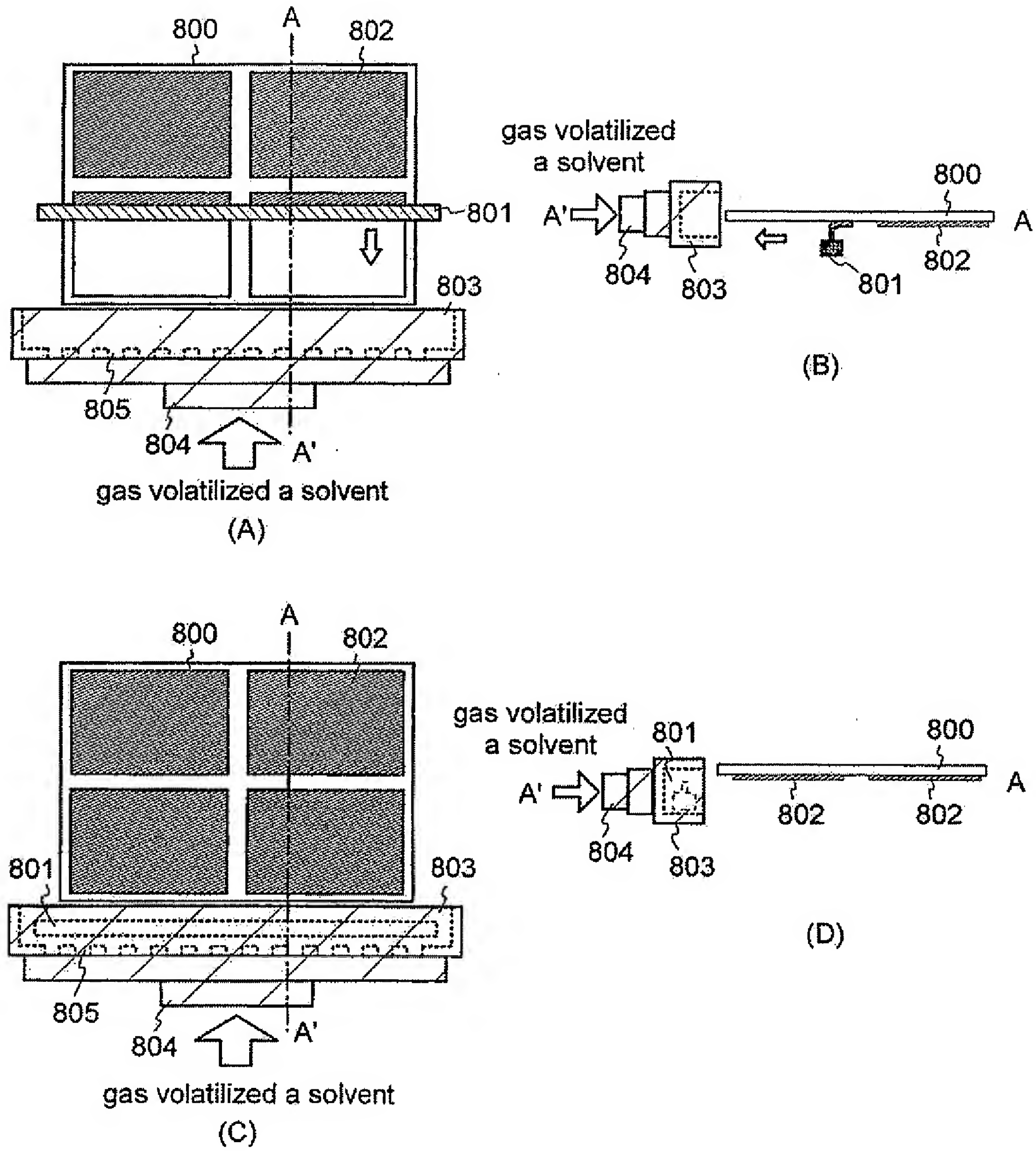
FIG. 11



(A)

(B)

FIG. 12



800
A
802
801
803
805
804
A'
gas volatilized a solvent
(A)
gas volatilized
a solvent
A'
804
803
801
800
802
A
(B)
800
A
802
801
803
805
804
A'
gas volatilized a solvent
(C)
gas volatilized
a solvent
801
800
A'
804
803
802
802
A
(D)

FIG. 13

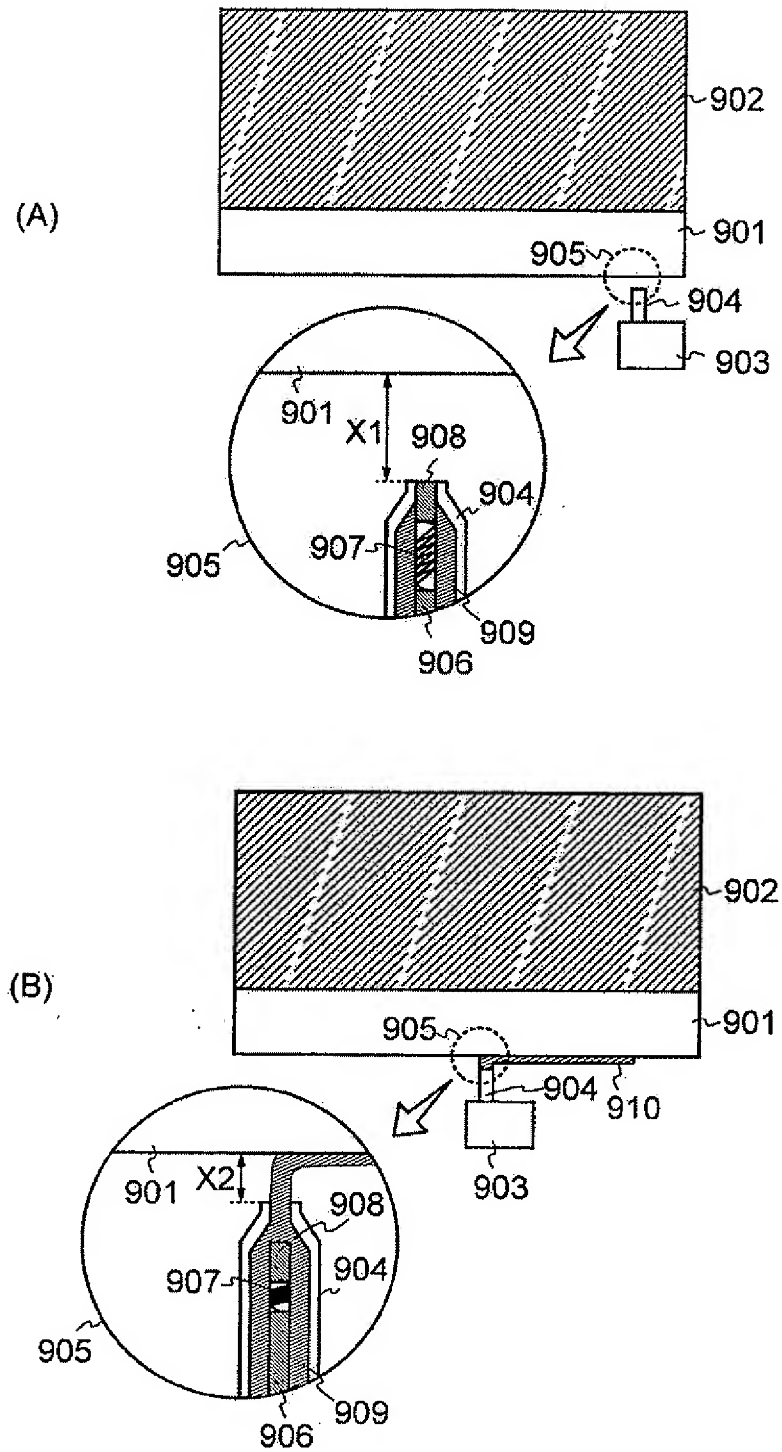
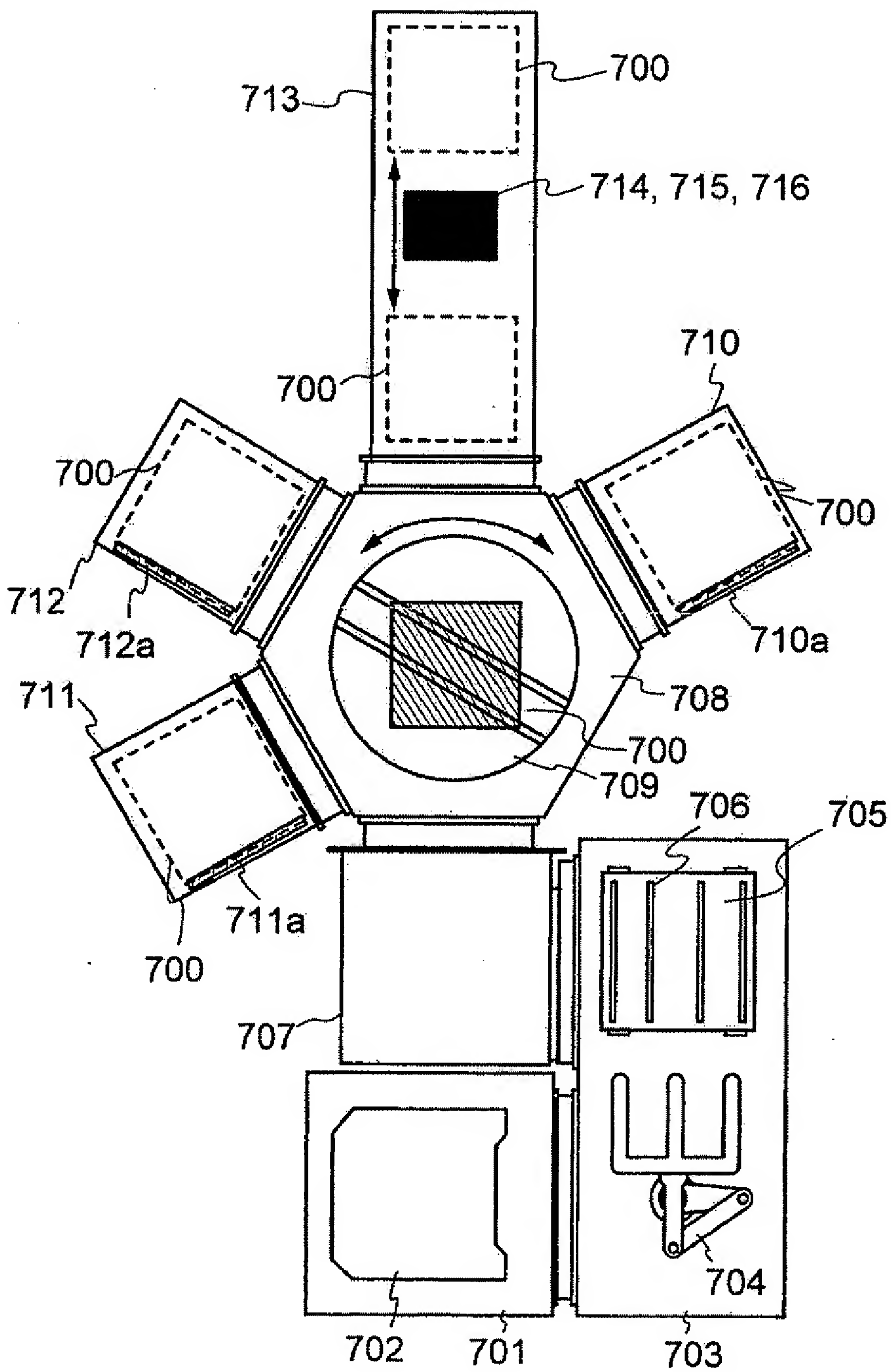

(A)
902
901
905
904
903
901
X1
908
904
907
905
909
906
(B)
902
901
905
904
910
903
901
X2
908
907
904
905
909
906

FIG. 14



700
713
714, 715, 716
710
700
700
700
712
712a
710a
711
708
700
709
706
705
711a
700
707
704
702
701
703

FIG. 15

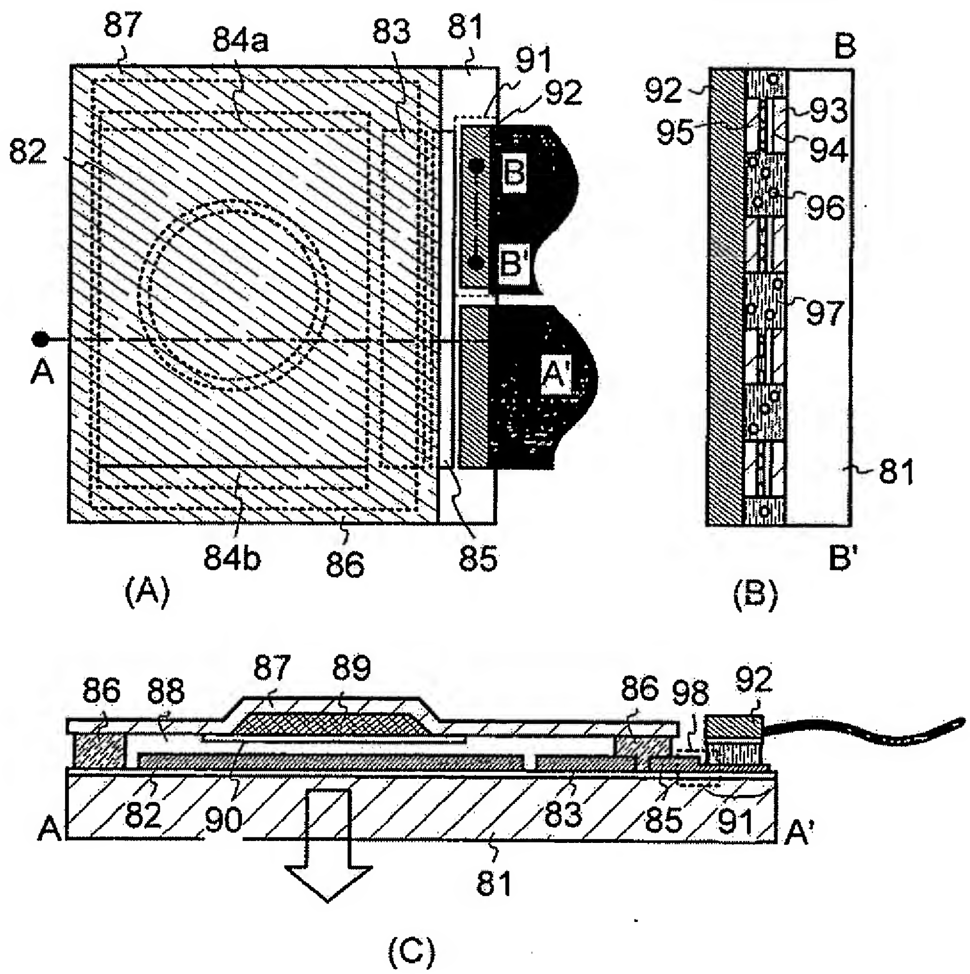
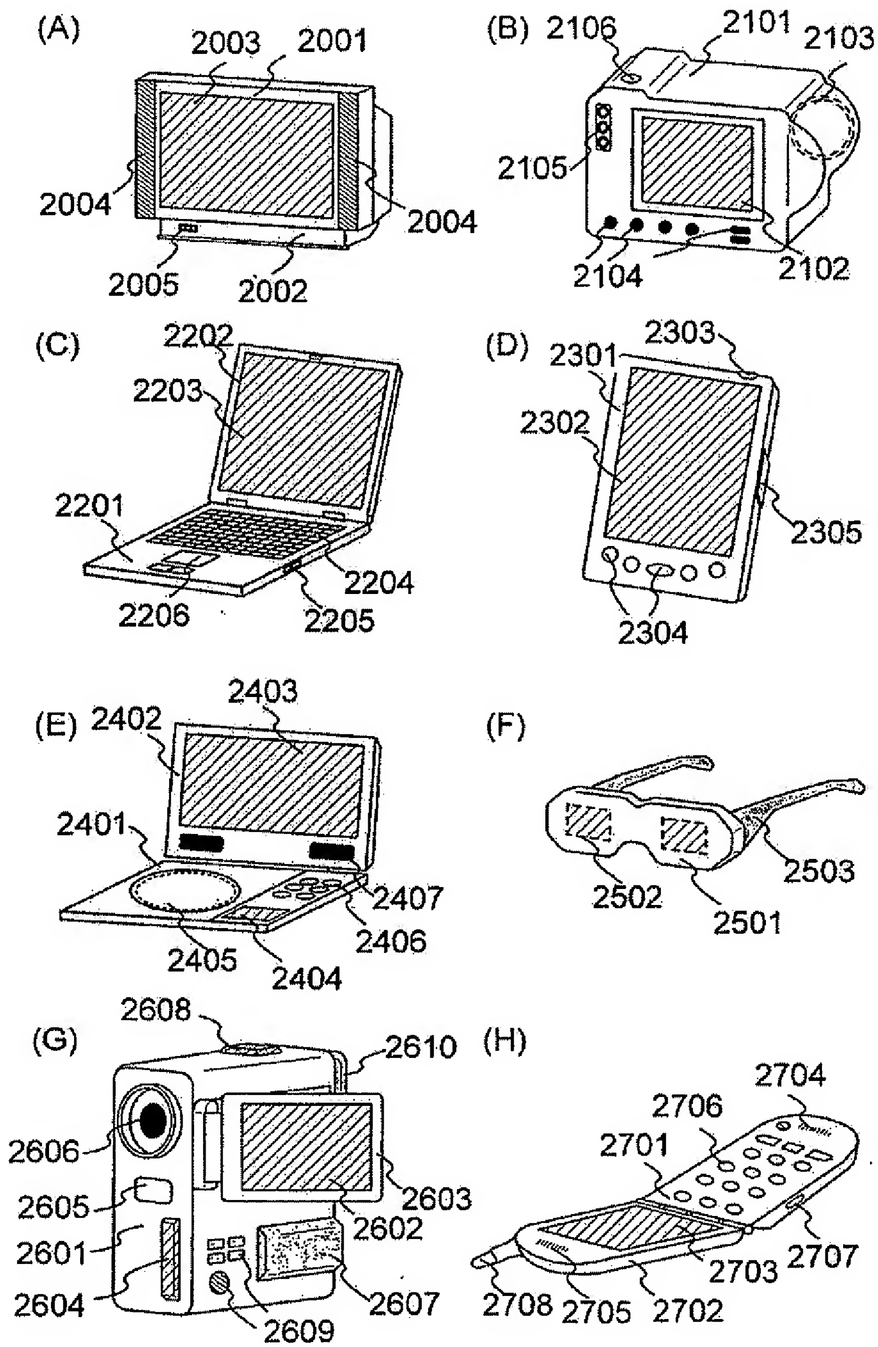

87
84a
83
81
91
92
82
B
B'
A
A'
84b
86
85
(A)
B
92
93
95
94
96
97
81
B'
(B)
86
88
87
89
86
98
92
82
90
83
85
91
A
A'
81
(C)

FIG. 16


(A)
2003
2001
2004
2004
2005
2002
(B)
2106
2101
2103
2105
2104
2102
(C)
2202
2203
2201
2204
2206
2205
(D)
2303
2301
2302
2305
2304
(E)
2402
2403
2401
2407
2406
2405
2404
(F)
2503
2502
2501
(G)
2608
2610
2606
2605
2601
2604
2603
2602
2607
2609
(H)
2704
2706
2701
2707
2703
2708
2705
2702